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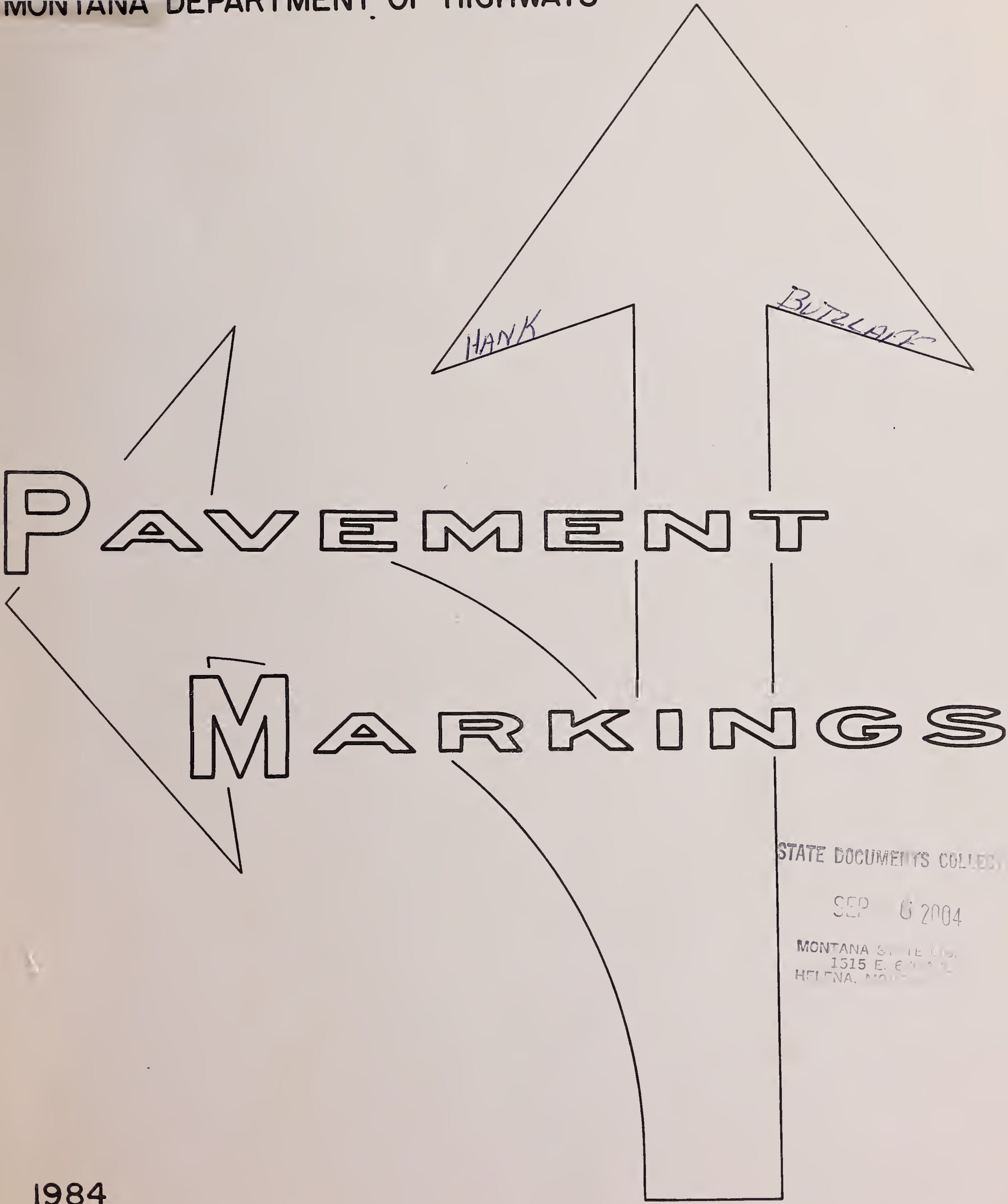

HANK BUTZLAFF

PAVEMENT MARKINGS

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PAVEMENT MARKINGS

A

Supplement

To The

MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES FOR STREETS AND HIGHWAYS

As Prepared By

Traffic Unit

Montana Department of Highways

Issued February 1, 1984

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MONTANA DEPARTMENT OF HIGHWAYS

Helena, Montana
May 1, 1978

TYPICAL PAVEMENT MARKINGS

Introduction

The standards for pavement markings contained in this manual are for the use of all who have the responsibility for providing pavement markings on the State highway system. These standards are to be considered a supplement to the Manual on Uniform Traffic Control Devices, covering in more detail those pavement markings most frequently used throughout the State.

Pavement markings have limitations in that they are not clearly visible under adverse weather conditions, are easily obliterated by snow and ice and their durability is limited when exposed to heavy traffic loads. They may also be obscured by vehicles immediately ahead of the observer.

Under favorable conditions pavement markings provide a definite aid to the driver by conveying necessary information to him without diverting his attention from the roadway. Continuous efforts to improve pavement marking materials have resulted in a general increase in their levels of visibility and durability under all driving conditions.

As traffic volumes continue to increase the need for markings to be easily recognized and readily understood becomes increasingly important. Therefore, when pavement markings are used as traffic control devices it is highly desirable that a uniform procedure governing their application, as outlined in this manual, be adhered to.

General

A. Reflectorization

All pavement markings shall be reflectorized by the use of glass beads, either pre-mixed or drop-on method or a combination of both methods.

B. Colors

Pavement markings shall be either white or yellow, conforming to standard highway color specifications. Word and symbol markings, crosswalk and crosswalk lines, channelization lines, stop lines, parking space markings and all lane lines other than the left edge line on one-way paved roads shall be white in color. Center lines, no passing barrier lines, medians, raised islands and left edge lines on all one-way roads shall be painted reflectorized yellow.

C. Materials

In urban areas where high traffic volumes create frequent need for maintenance, plastic pavement markings should be used for all but parking areas. Paved rural roads shall be striped with either paint or plastic.

Pavement Markings

A. Center Lines

1. Rural, two lanes, two-way - A broken yellow line, 4 inches wide, consisting of 10 foot painted segments with 30 foot gaps between segments (Figure 1).

2. Rural or urban, four or more lanes, two-way - Two solid yellow lines, 4 inches wide, separated by a space of not less than 4 inches (Figure 1).

3. Urban, two lane-two way - These streets generally have a broken yellow centerline, 4 inches wide. On two-lane, one-way streets the centerline is a lane line and shall be a broken white line, 4 inches wide. Both lines will be segmented with either a 9 foot painted stripe followed by a 15 foot gap, or a 10 foot painted stripe followed by a 30 foot gap.

   When desirable, the centerline within city limits or an urban area may be striped with two solid yellow lines 4 inches wide and spaced 4 inches apart.

B. Lane Lines

1. Rural roads - Lane lines shall be a broken white line, 4 inches wide, consisting of 10 foot painted segments with 30 foot gaps between segments (Figure 1).

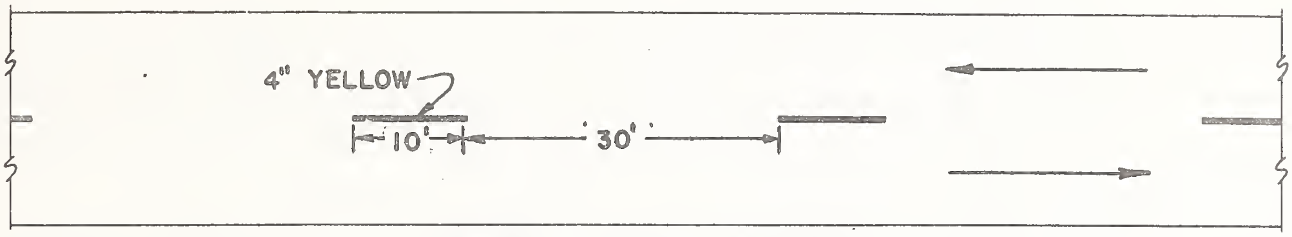
2. Urban streets - Lane lines shall be broken white lines, 4 inches wide and segmented with either 9 foot long painted stripes followed by a 15 foot gap, or a 10 foot painted stripe followed by a 30 foot gap.

3. High speed boulevards - High speed boulevards and controlled access highways in urban areas will be marked the same as rural highways.

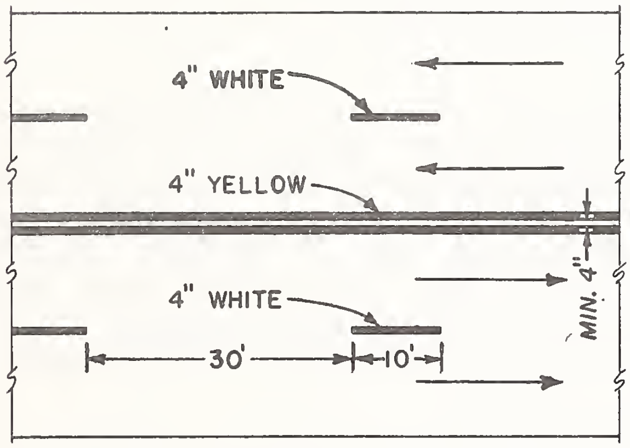
C. Pavement Edge Lines or Shoulder Lines

1. Solid white 4 inch edge lines shall be used to delineate the edges of the traveled way wherever the paved roadway surface width is 24 feet or greater. Divided multi-lane highways shall have inside and outside shoulders striped. Where the median is paved flush with the traffic lanes, a solid yellow 8 inch barrier line shall be used adjacent to the median. Where a painted raised median is adjacent to a lane which has a minimum width of 14 feet a solid yellow lane line may be painted adjacent to and parallel with the median.

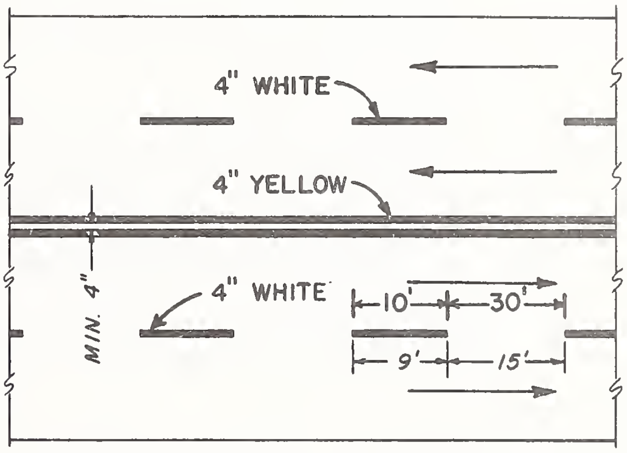
STANDARD PAVEMENT MARKINGS



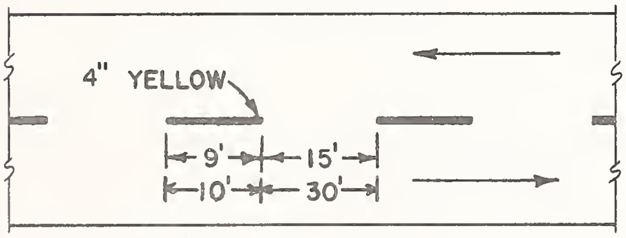
TWO - LANE RURAL
TWO-WAY



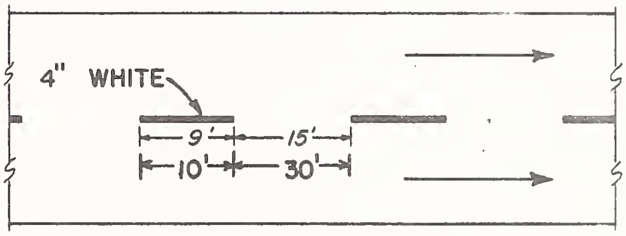
FOUR - LANE UNDIVIDED
RURAL



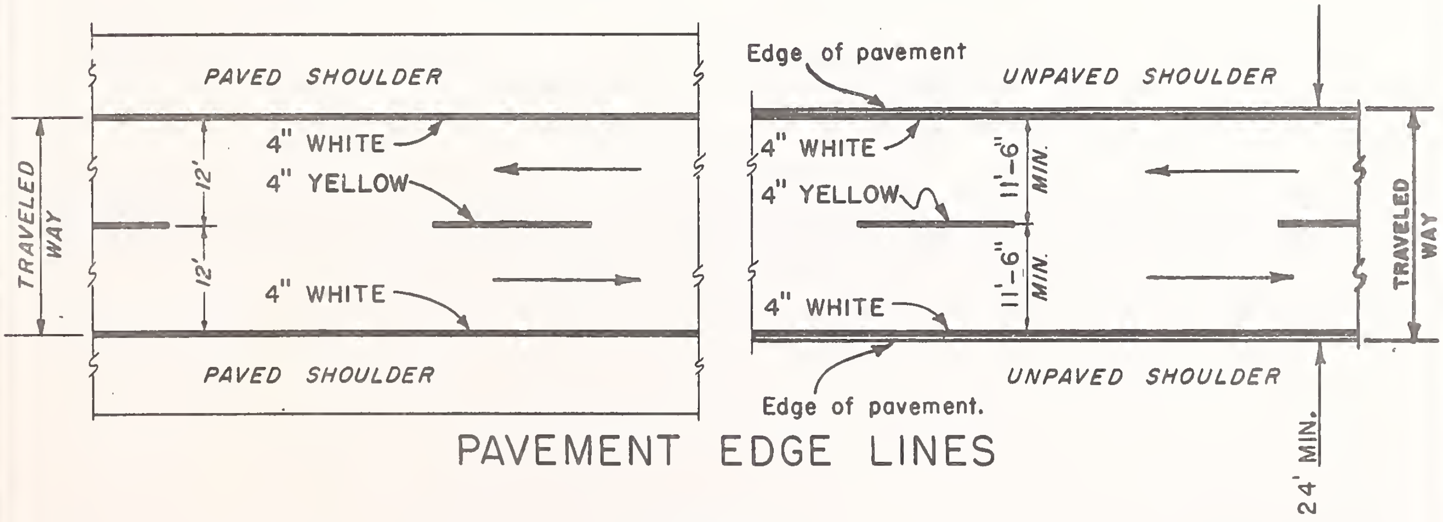
FOUR - LANE UNDIVIDED
URBAN



URBAN STREET
TWO - WAY



URBAN STREET
ONE - WAY



PAVEMENT EDGE LINES

FIGURE 1

D. No-Passing Zones

No-passing zones shall be marked by a solid yellow, 4 inch wide, barrier line placed on the right-hand side of a center or another barrier line. The marking for no-passing in either direction shall be two solid yellow barrier lines, each being 4 inches wide and separated by a space of not less than 4 inches.

No-passing zones are warranted when the sight distance ahead is less than the minimum sight distance required for safe passing. Safe passing sight distances, for various highway speed ratings, are shown in Table No. 1. No-passing zones are also warranted in advance of areas where passing is particularly hazardous, such as narrow bridges and certain intersections.

Sight distance on a vertical curve is the distance at which an object 3.50 feet above the pavement can just be seen from an observation point 3.50 feet above the pavement, as illustrated in Figures 2 and 3. Similarly, sight distance on a horizontal curve is the distance, measured along the centerline, at which an object 3.50 feet above the pavement is just visible from an observation point 3.50 ~~3.75~~ feet above the pavement, on a line of sight tangent to an obstruction that cuts off the view on the inside of the curve.

TABLE NO. 1

85% Speed on Highway M.P.H.	Highway characteristics that may be used to classify speed rating in lieu of determination of 85% speed.	Minimum Passing Sight Distance
50	Pavement Width - 22 feet or more	800 feet
	Horizontal Curve - Maximum 7°30'	
	Vertical Curve - Min. K. Value = 85	
60	Pavement Width - 24 feet	1,000 feet
	Horizontal Curve - Maximum 5°	
	Vertical Curve - Min. K. Value = 160	
70	Pavement Width - 28 feet or more	1,200 feet
	Horizontal Curve - Maximum 3°30'	
	Vertical Curve - Min. K. Value = 255	

K value, as shown above, is a co-efficient by which the algebraic difference in grade may be multiplied to determine the length in feet of the vertical curve which will provide minimum stopping sight distance.

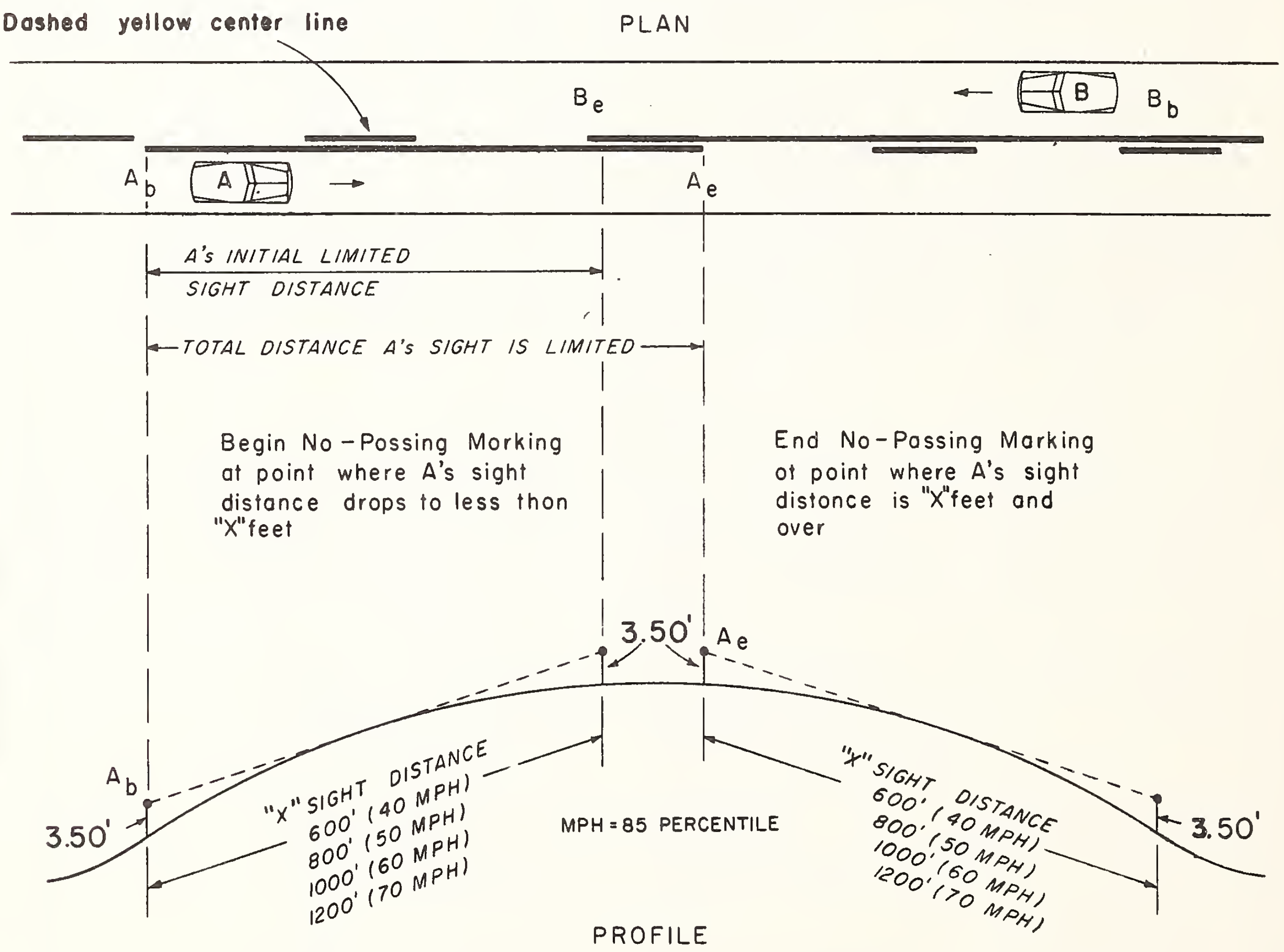
The minimum length of a No-Passing zone in a rural area shall be 500 feet. If the actual No-Passing distance is less than 500 feet in length, the additional length of marking shall be added at the beginning.

When the distance between the end of one No-Passing zone and the beginning of the following No-Passing zone is less than 400 feet, the zones shall be extended through the intervening distance (Figure 3).

When two paved highways intersect, the approaches to the intersection shall be striped as No-Passing zones for a distance of 300 feet in urban areas and 500 feet in rural areas (Figure 5).

VERTICAL CURVE ~ TWO-LANE PAVEMENT

WHERE SIGHT DISTANCE IS LESS THAN "X" FEET

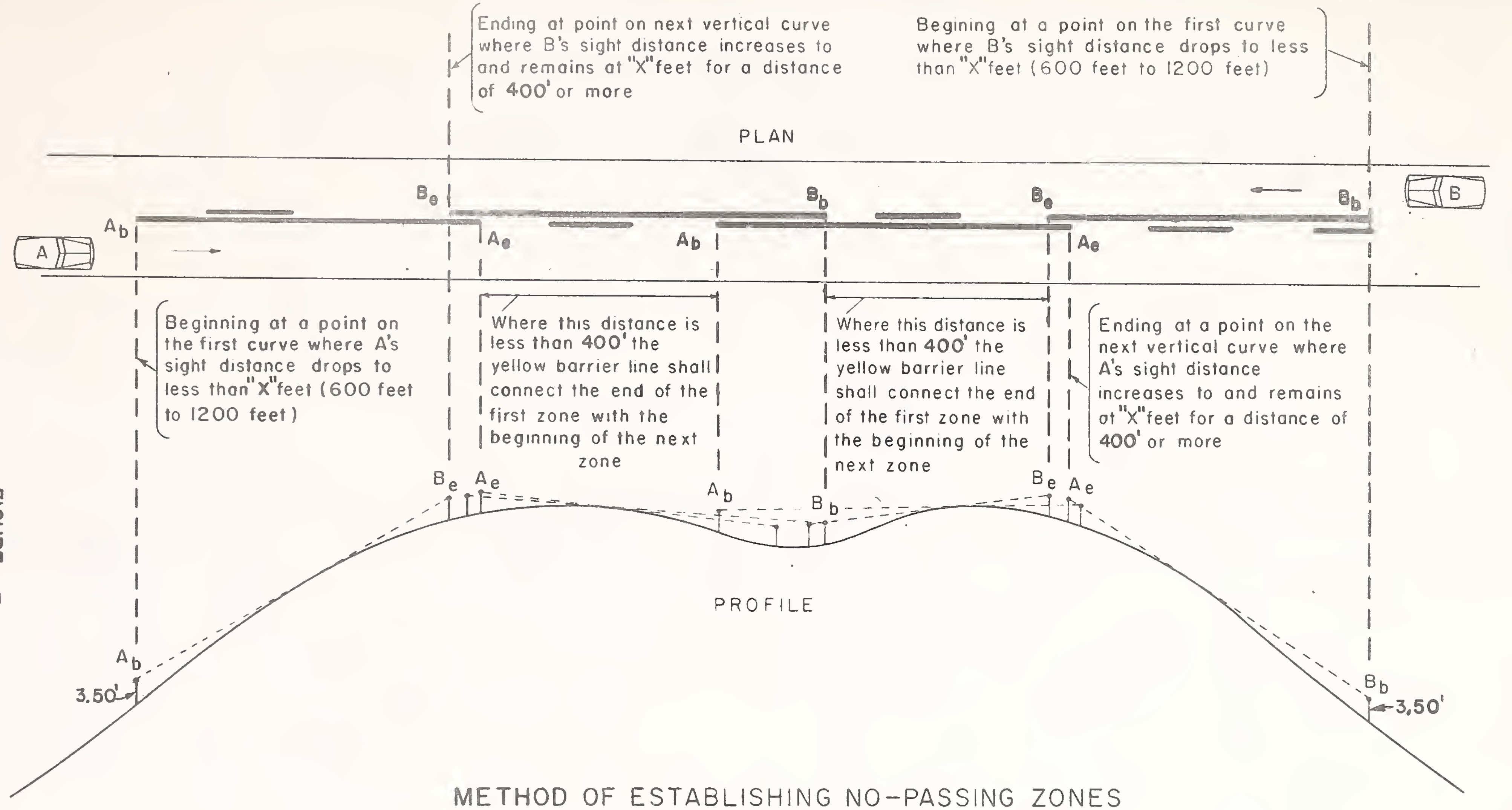


Begin No-Passing Marking at point where A's sight distance drops to less than "X" feet

End No-Passing Marking at point where A's sight distance is "X" feet and over

Note: The method of establishing the no-passing markings, as shown on the profile, is for A's direction only The method for B's direction is similar

FIGURE 2



Ending at point on next vertical curve where B's sight distance increases to and remains at "X" feet for a distance of 400' or more

Begining at a point on the first curve where B's sight distance drops to less than "X" feet (600 feet to 1200 feet)

Beginning at a point on the first curve where A's sight distance drops to less than "X" feet (600 feet to 1200 feet)

Where this distance is less than 400' the yellow barrier line shall connect the end of the first zone with the beginning of the next zone

Where this distance is less than 400' the yellow barrier line shall connect the end of the first zone with the beginning of the next zone

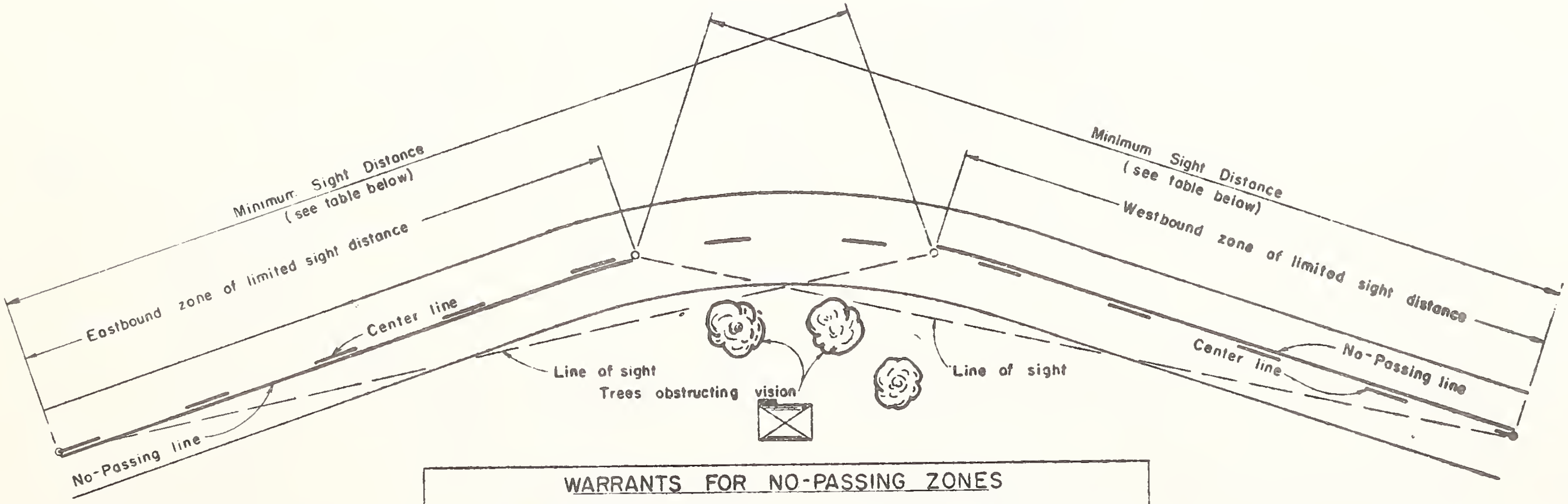
Ending at a point on the next vertical curve where A's sight distance increases to and remains at "X" feet for a distance of 400' or more

METHOD OF ESTABLISHING NO-PASSING ZONES
FOR SUCCESSIVE VERTICAL CURVES*
ON TWO-LANE PAVEMENTS

* Successive horizontal curves on two-lane pavements shall be marked similarly

FIGURE 3

NO - PASSING LINES ON HORIZONTAL CURVES



WARRANTS FOR NO-PASSING ZONES

85 PERCENTILE SPEED (mile per hour)	MINIMUM SIGHT DISTANCE (feet)
30	500
40	600
50	800
60	1000
70	1200

NOTES

① Begin the No-Passing line when the measured line of sight becomes less than the minimum sight distance

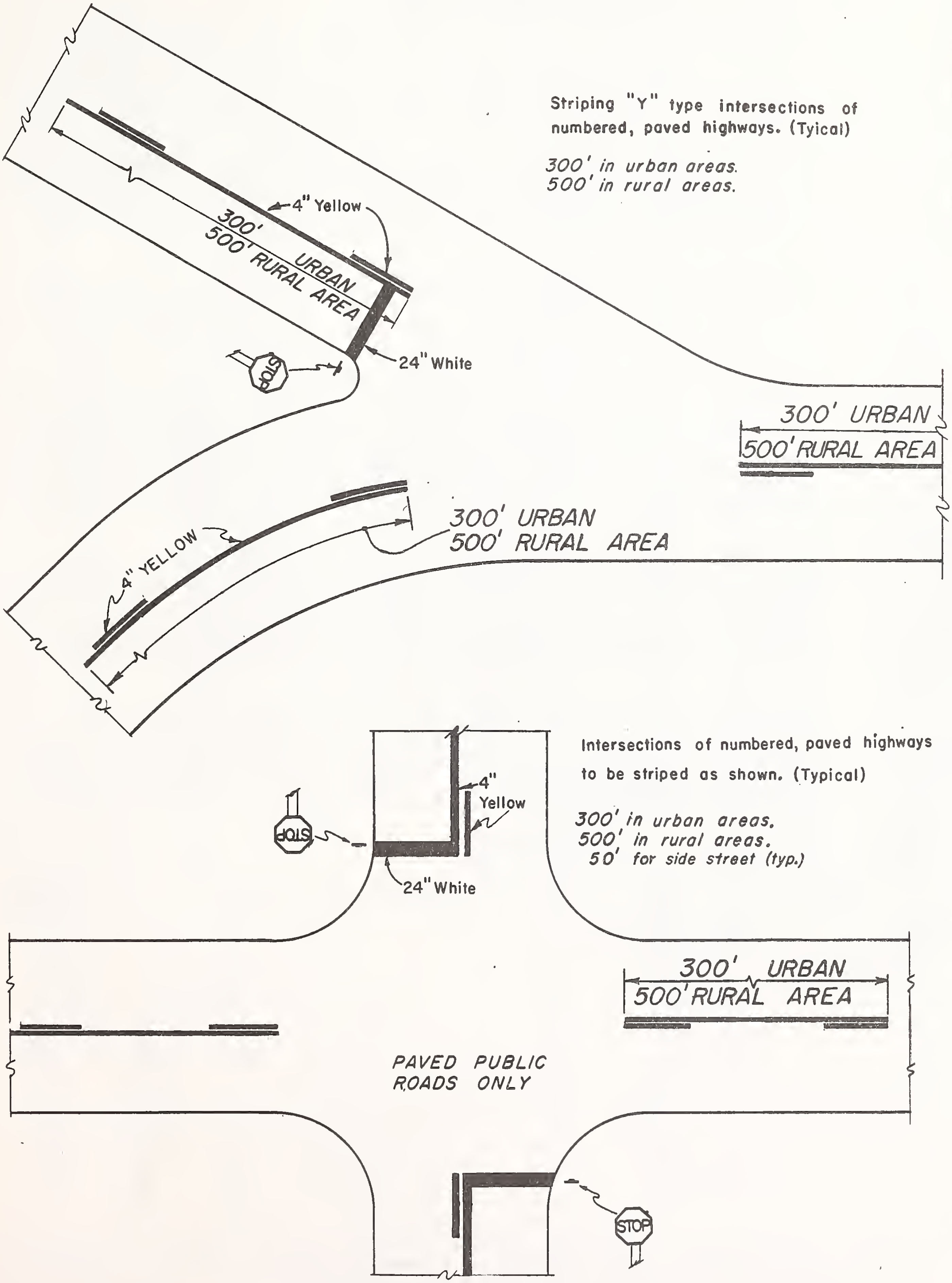
② End the No-Passing line when the measured line of sight again exceeds the minimum sight distance.

③ Consult Table for the minimum sight distance determined by the 85th. percentile speed.

④ The No-Passing lines may or may not overlap depending on the alinement.

FIGURE 4

NO-PASSING ZONES AT INTERSECTIONS



Striping "Y" type intersections of numbered, paved highways. (Tyical)

300' in urban areas.
500' in rural areas.

Intersections of numbered, paved highways to be striped as shown. (Typical)

300' in urban areas.
500' in rural areas.
50' for side street (typ.)

FIGURE 5

E. No-Passing Zones for Narrow Bridges

Pavement markings for narrow bridges should consist of center lines, No-Passing barrier lines and edge lines. If no centerlines exist on the structure they should be added within the limits of the treatment area. The No-Passing barrier line on these roads should begin 1500 feet in rural areas, and 300 feet in urban areas, in advance of the end of the restricted structure. In the case of two-lane structures the No-Passing barrier line should be continued across the structure to a point where the full roadway width is resumed. The No-Passing barrier line may require lengthening on approaches where the road has restricted vertical and/or horizontal sight distances.

On roads having narrow one-lane bridges, double solid yellow barrier lines should begin at a point 1500 feet in rural areas, and 300 feet in urban areas, in advance of the end of the restricted structure. They should continue to the point at which the pavement width begins to narrow. A stop line should be provided at this point to indicate the holding area for a vehicle awaiting the approach of another vehicle that is entering or already within the one-lane section. Adequate space must be provided for a smooth transition from a one-lane structure to a two-way roadway. This transition must allow the oncoming vehicle to properly meet and pass another vehicle waiting at the stop line.

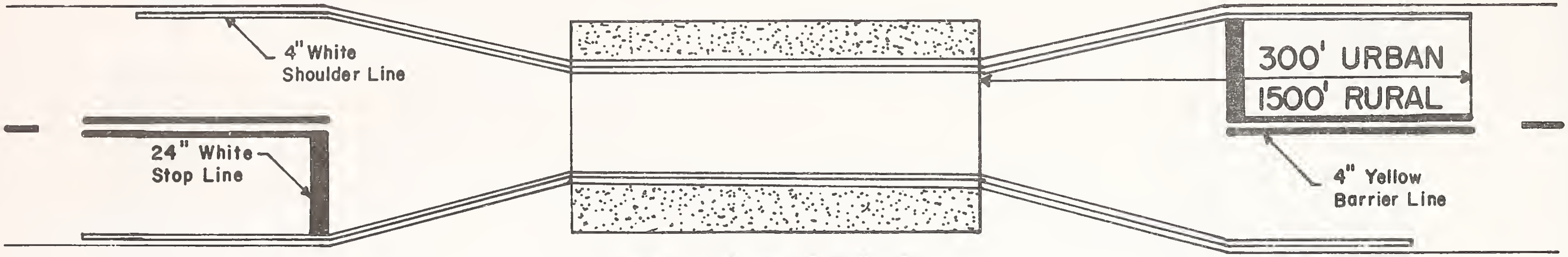
Solid white edge lines a minimum of 4 inches wide should be placed on both sides of the pavement beginning and ending approximately 1500 feet in rural areas, and 300 feet in urban areas, ahead of and beyond the structure. Markings on one-lane bridges should create a funnel effect and provide for a single lane across the bridge.

Table 2 identifies the widths at or below which a bridge on a two-lane highway can be considered to be a narrow bridge. This table is the result of subjective application of functional type of road, percentage of commercial vehicles (includes large recreational vehicles and farm vehicles), and average daily traffic.

TABLE NO. 2

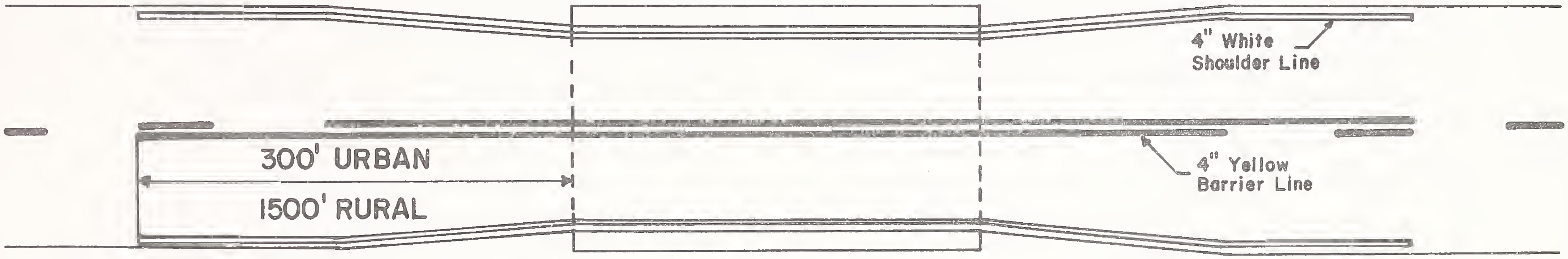
TYPE	ADT Vehicles per Day	COMMERCIAL VEHICLE Percent	WIDTH* Feet
Minor Road	0-250	0-10	20
		Over 10	22
	251-750	0-10	22
		Over 10	24
	Over 750	0-10	26
		Over 10	28
Major Road	750 or Less	0-10	24
		Over 10	26
	Over 750	0-10	28
		Over 10	30

*Bridges with widths (clear width between curbs or rails, whichever is lesser) equal to or less than values shown are classed as narrow bridges. Regardless of the classification or other conditions, any bridge which has a width less than the approach traveled way should definitely be considered as a narrow bridge.



ONE LANE BRIDGE

Striping on structures less than
24' in width, curb to curb, with no
other restrictions on sight distance:
300' in urban areas.
1500' in rural areas.



TWO-LANE NARROW BRIDGE

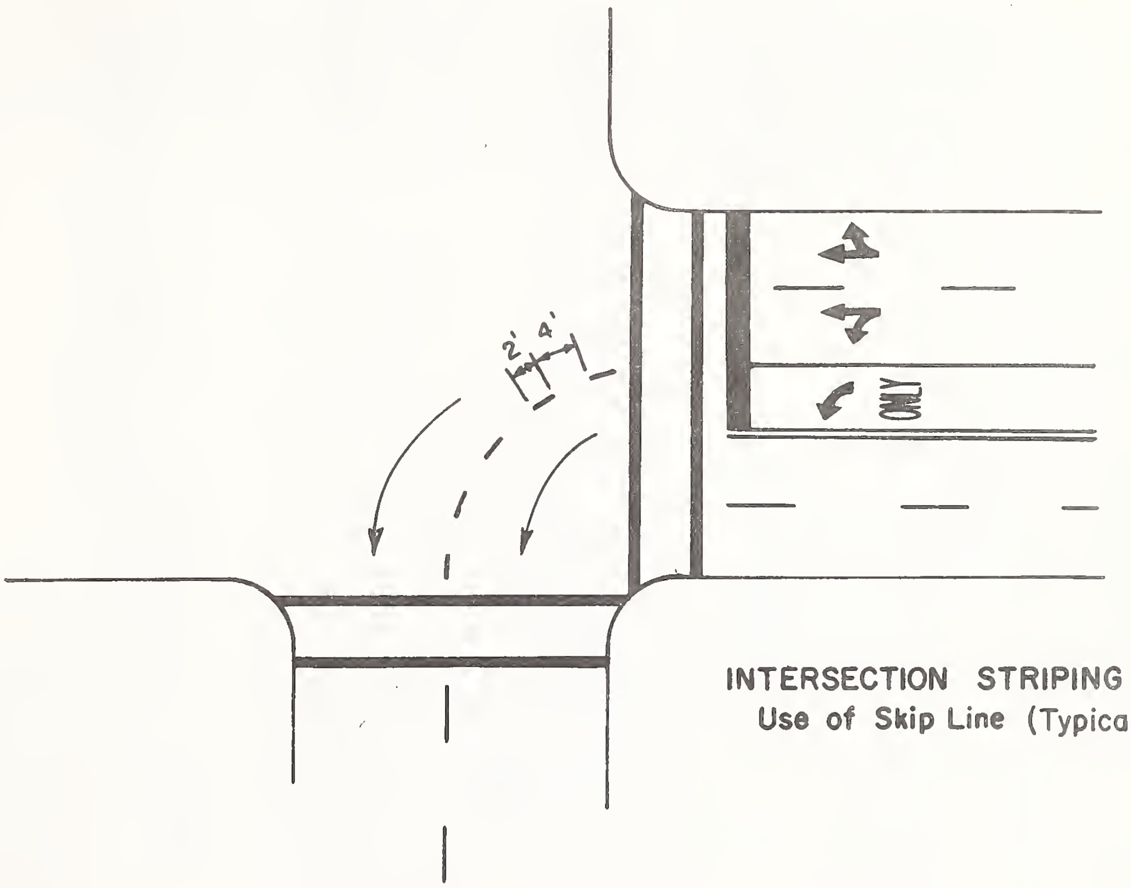
NO-PASSING ZONES FOR APPROACHES TO NARROW TWO-LANE BRIDGES

FIGURE 6

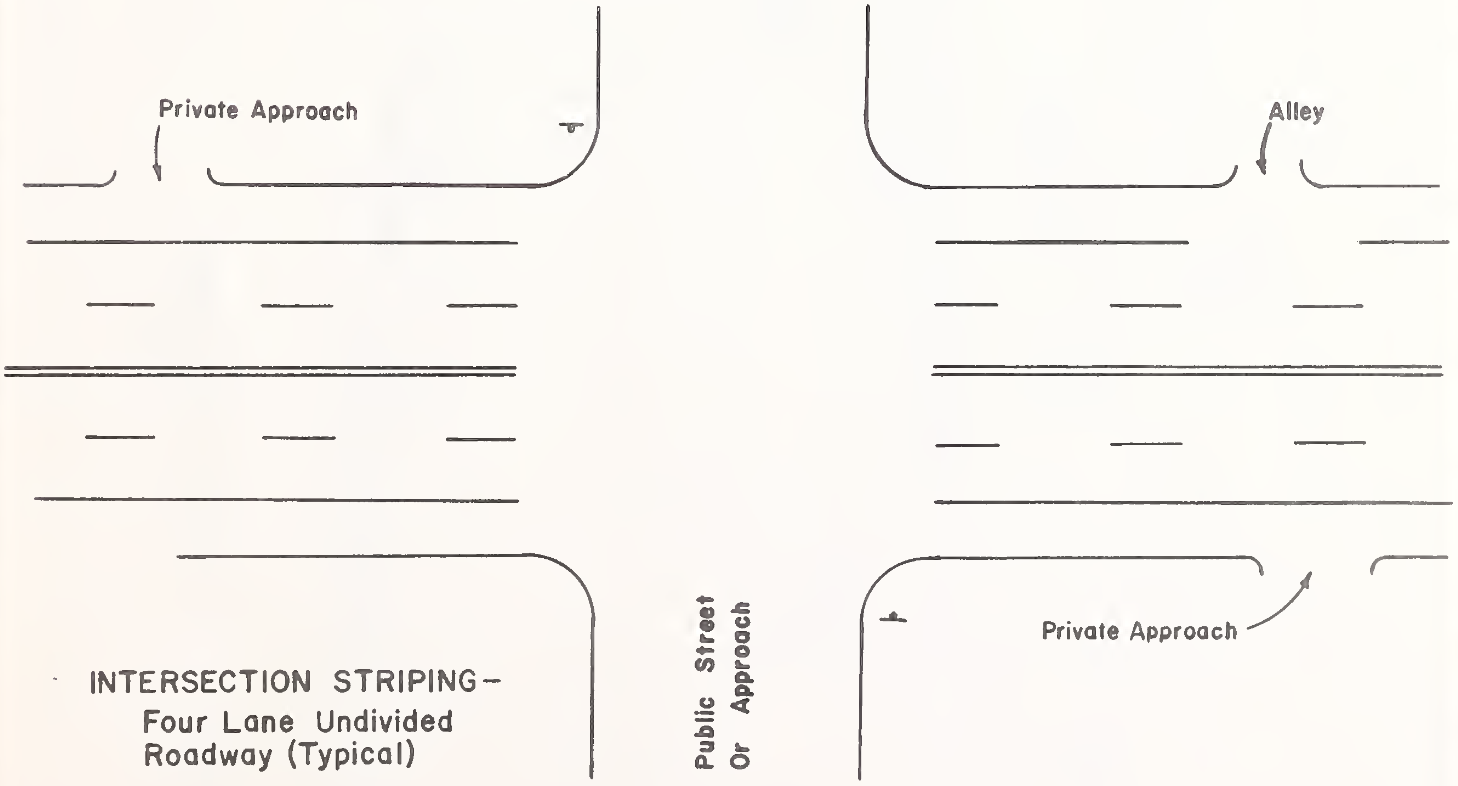
F. Striping Through Intersections

Ordinarily centerlines and lane lines will not be continued through an intersection of any public side road approach. Under no circumstances will the pavement edge lines be carried through an intersection. Centerlines, lane lines and edge lines will not be broken for private driveways or approaches. If there is a need to provide guidance to vehicles through an intersection area because of difficult geometrics or sight distance restrictions, center-lines and lane lines may be extended by the use of skiplines. Skiplines will be the same width and color as the lines which they are used to extend. They will be two feet in length and have gaps normally four to ten feet.

INTERSECTION STRIPING



INTERSECTION STRIPING
Use of Skip Line (Typical)



INTERSECTION STRIPING—
Four Lane Undivided
Roadway (Typical)

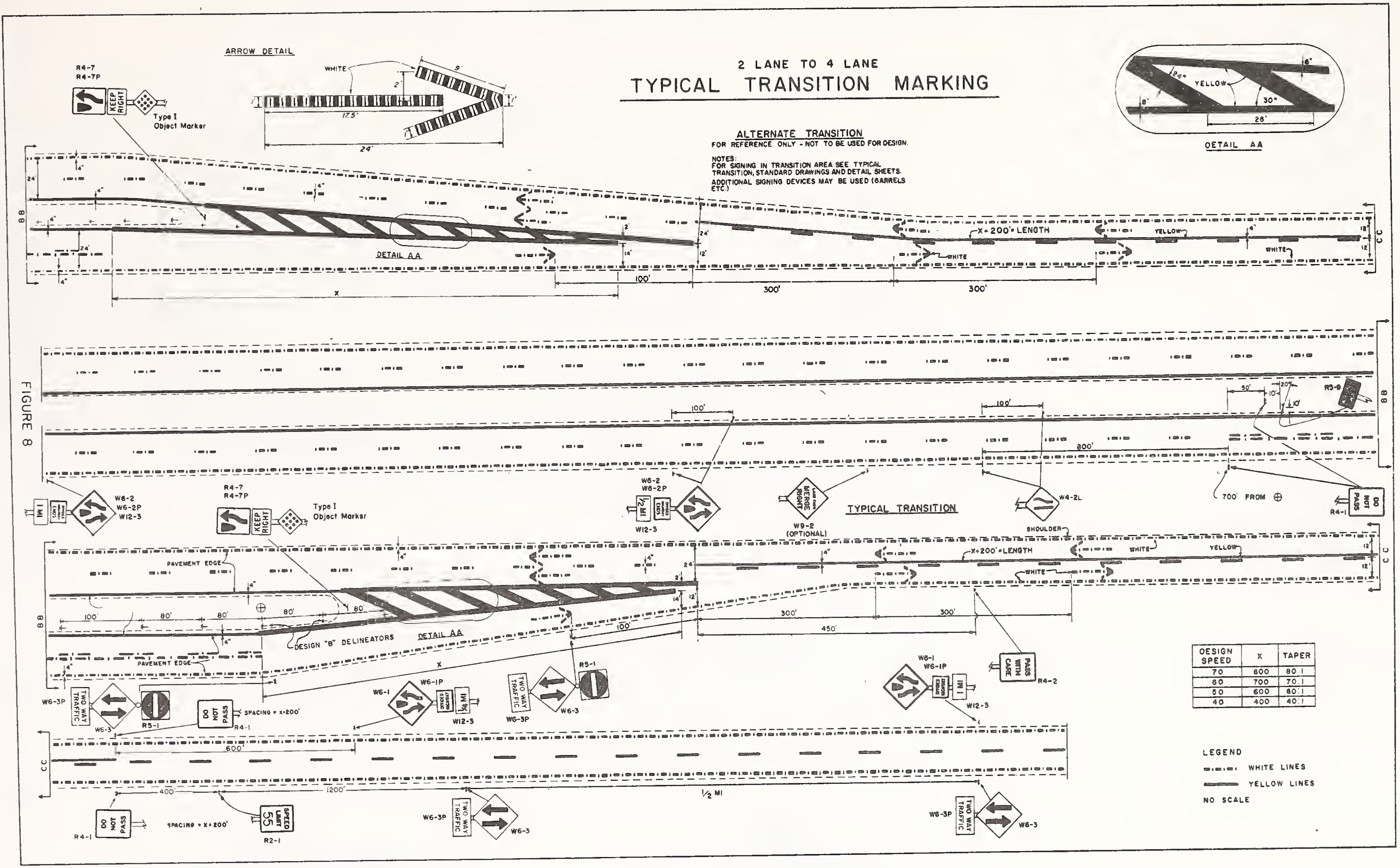
FIGURE 7

G. Transitions

Pavement markings at transitions should be laid out very carefully. Uniformity is a must, due to higher speed encountered at the interstate transitions and the increase in the number of such facilities. A number of situations are possible; however, two typical transitions are illustrated in Figure 8.

2 LANE TO 4 LANE

TYPICAL TRANSITION MARKING



ALTERNATE TRANSITION

FOR REFERENCE ONLY - NOT TO BE USED FOR DESIGN.

NOTES:
FOR SIGNING IN TRANSITION AREA SEE TYPICAL TRANSITION, STANDARD DRAWINGS AND DETAIL SHEETS.
ADDITIONAL SIGNING DEVICES MAY BE USED (BARRELS ETC.)

DESIGN SPEED	X	TAPER
70	600	80:1
60	700	70:1
50	600	60:1
40	400	40:1

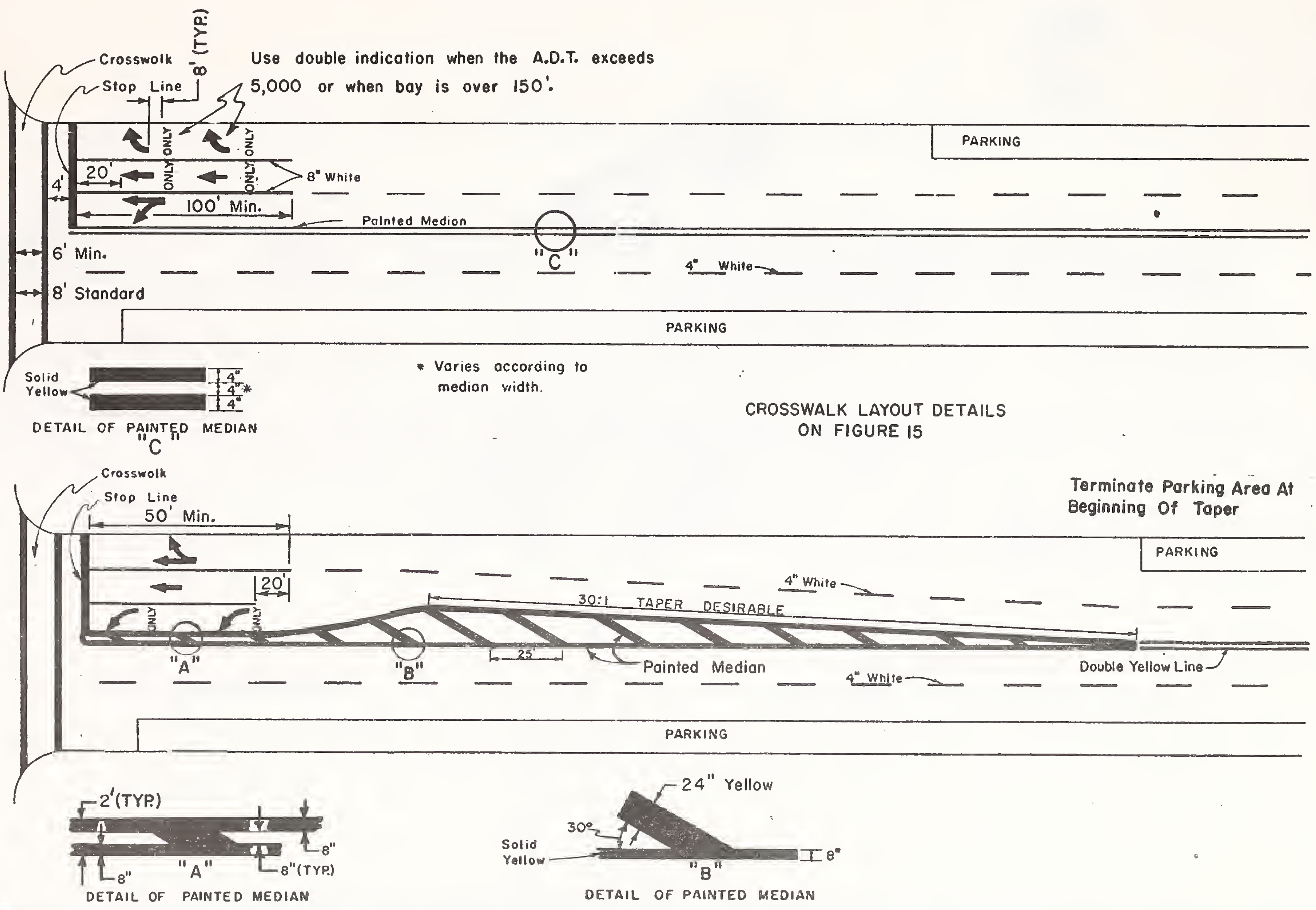
LEGEND
▬ · ▬ · ▬ WHITE LINES
▬▬▬ YELLOW LINES
NO SCALE

FIGURE 8

H. Channelization

The channelizing line shall be a solid white line, generally 8 to 12 inches in width. Figures 9, 10 and 11 illustrate some typical uses of this line; however, the Manual on Uniform Traffic Control Devices lists many other uses of the line.

TYPICAL LANE - USE - CONTROL MARKINGS



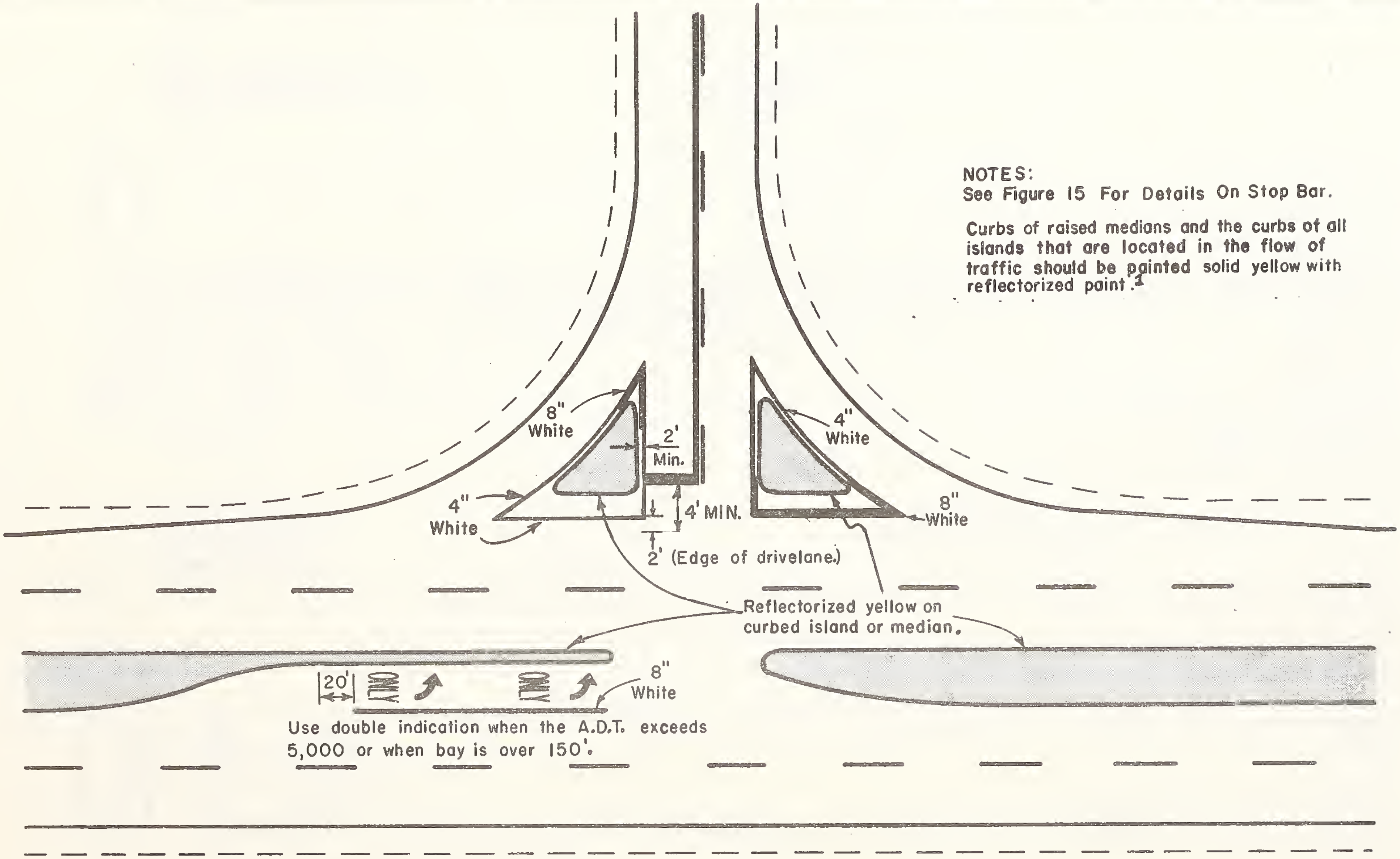
Use double indication when the A.D.T. exceeds 5,000 or when bay is over 150'.

* Varies according to median width.

CROSSWALK LAYOUT DETAILS ON FIGURE 15

Terminate Parking Area At Beginning Of Taper

FIGURE 9



NOTES:
See Figure 15 For Details On Stop Bar.

Curbs of raised medians and the curbs of all islands that are located in the flow of traffic should be painted solid yellow with reflectorized paint.[1]

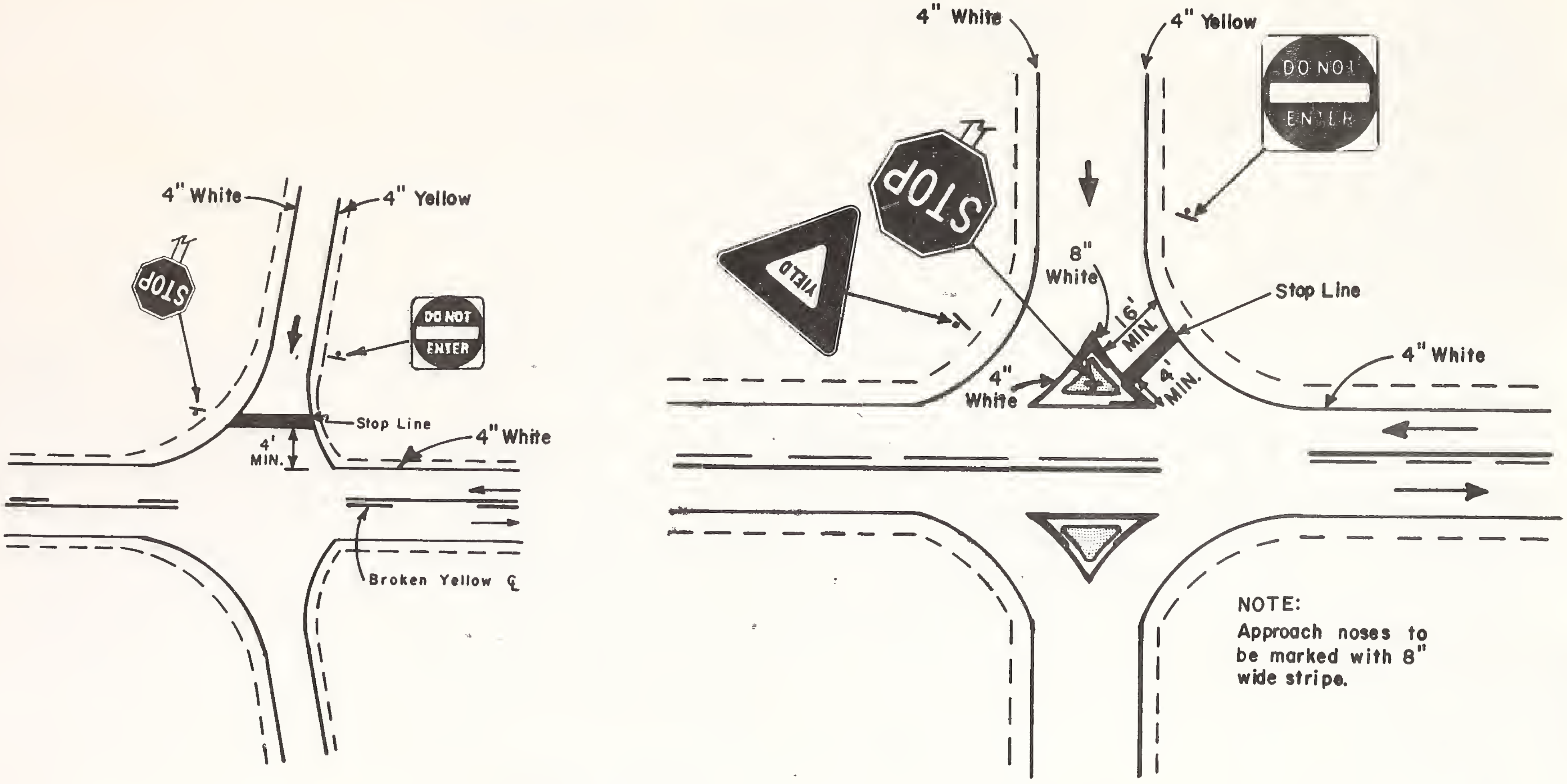
CHANNELIZATION MARKINGS

FIGURE 10

---

[1] A.A.S.H.O., A POLICY ON GEOMETRIC DESIGN OF RURAL HIGHWAYS, (1965 EDITION), p375.

TYPICAL RAMP TERMINAL MARKINGS



UN-CHANNELIZED

CHANNELIZED

NOTE:
Approach noses to be marked with 8" wide stripe.

FIGURE 11

I. Two-Way Left-Turn Lanes

Two-way left-turn lanes are designed to remove left-turning vehicles from the through lanes and store those vehicles in the median area until a gap in opposing traffic appears. The two-way left-turn lane provides a "harbor" in which turning vehicles are sheltered from both streams of through lane traffic. The two-way left-turn lane should be 12 feet in width (10 feet minimum) with a 2 foot buffer zone on each side.

TWO-WAY LEFT-TURN LANE

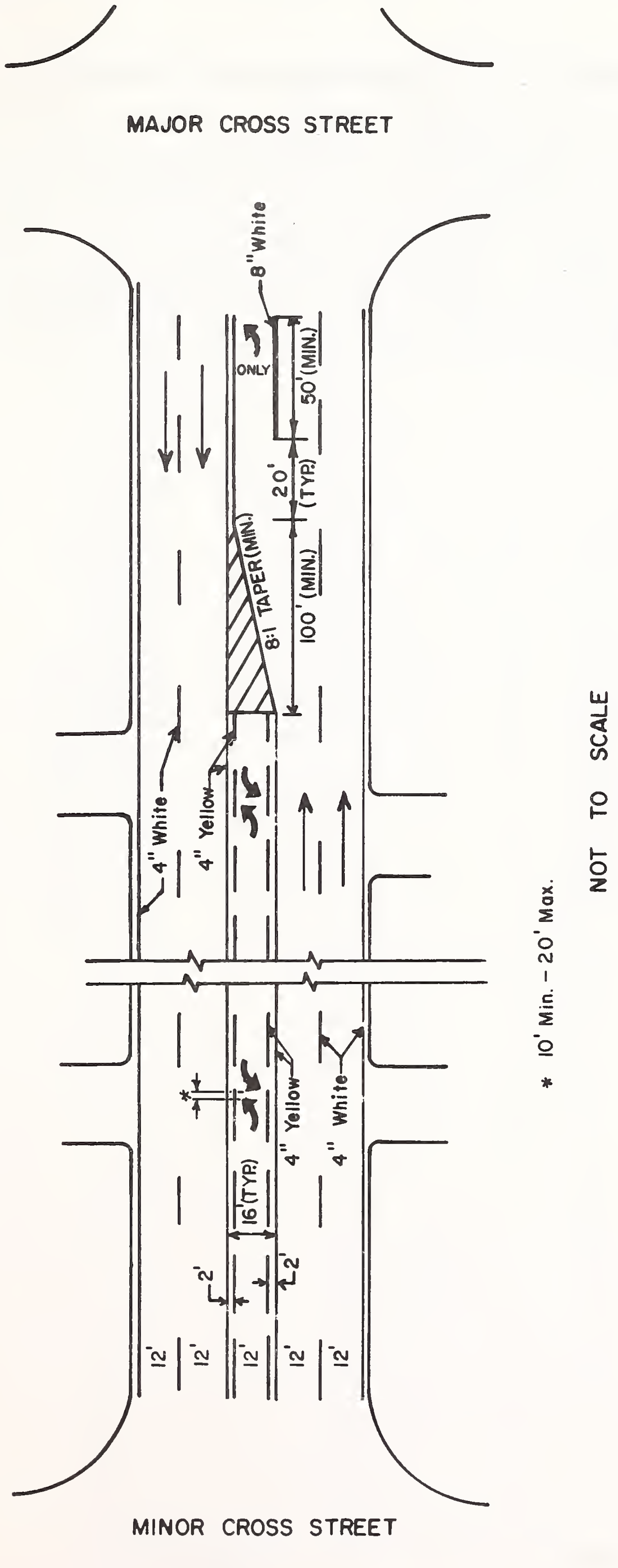
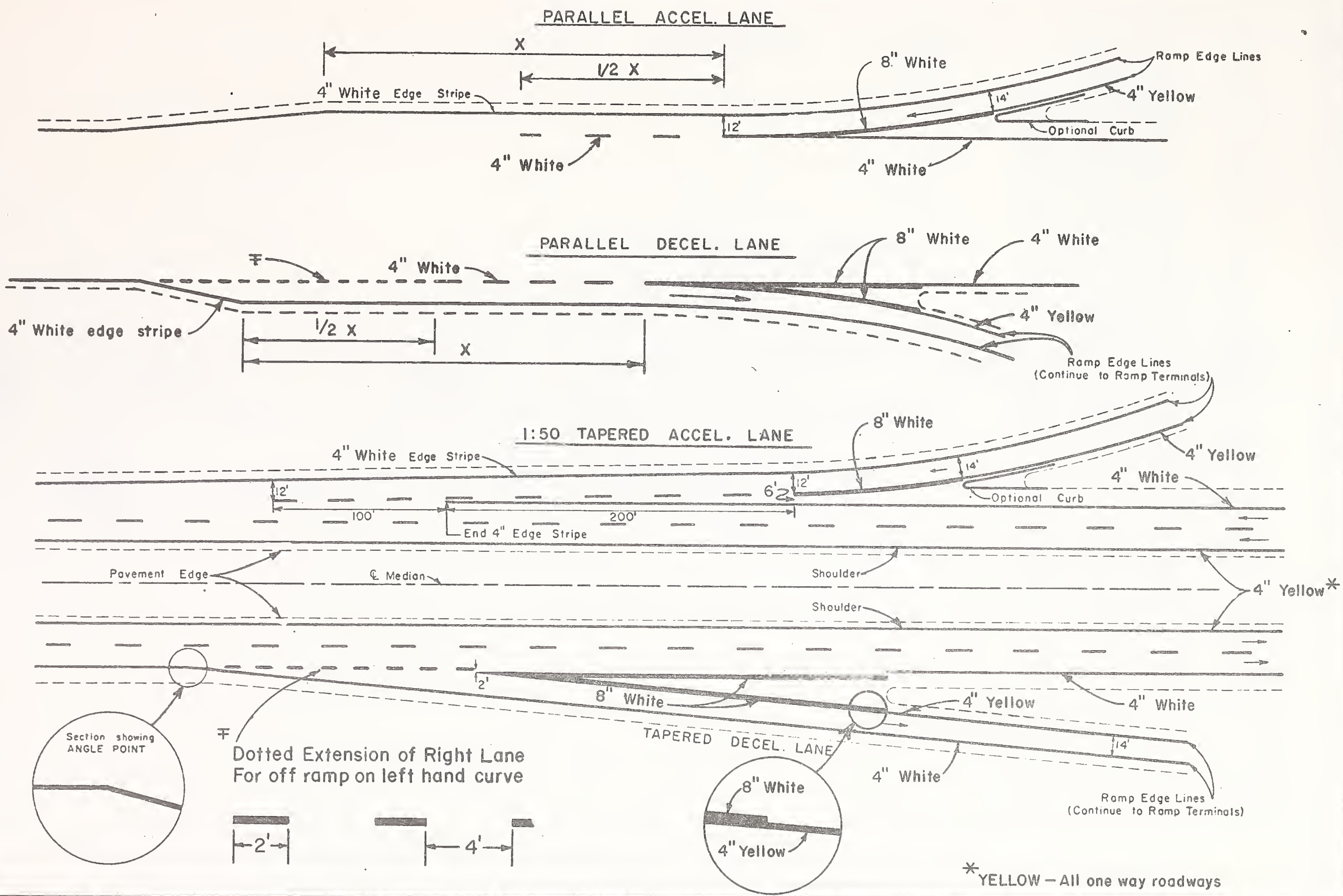


FIGURE 12

J. Acceleration and Deceleration Lane Markings

Geometric design sets rigid controls on acceleration and deceleration lane markings. Because the function of the facility depends so much on proper markings, it is immperative that each acceleration and deceleration lane is carefully laid out, using the road plans as a guide. Figure 13 illustrates the proper markings and their locations. Figures 20 and 21 show the use of striping layout symbols at intersections. A definite angle point must be evident to the approaching vehicle in order to distinguish the ramp exist from the main travel lane.

TYPICAL ACCEL. & DECEL. LANE MARKINGS



∓ Dotted Extension of Right Lane
For off ramp on left hand curve

*YELLOW – All one way roadways

FIGURE 13

K. Truck Climbing Lanes

Truck climbing lanes should not be striped unless at least 36 feet of surfacing is available for use as a traveled way.

The centerline on truck climbing lanes is striped for no-passing on the uphill lane throughout the entire length of the additional widening. No-passing zones on the downhill lane are limited to those areas where the sight distance is less than shown on Table I. The tapers used to introduce the additional lane should be delineated by the use of a shoulder or pavement edge stripe. Care should be used in laying out the angle points in order to define the beginning and end of the widening (Figure 14).

TRUCK CLIMBING LANES

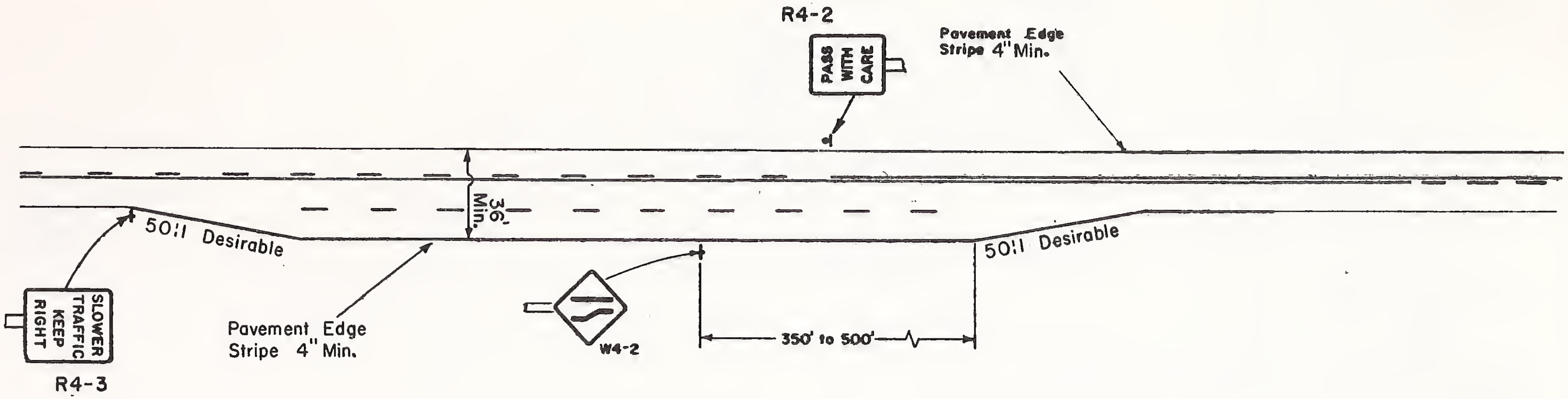

R4-2
PASS WITH CARE
Pavement Edge Stripe 4" Min.
36' Min.
50:1 Desirable
50:1 Desirable
SLOWER TRAFFIC KEEP RIGHT
R4-3
Pavement Edge Stripe 4" Min.
W4-2
350' to 500'

FIGURE 14

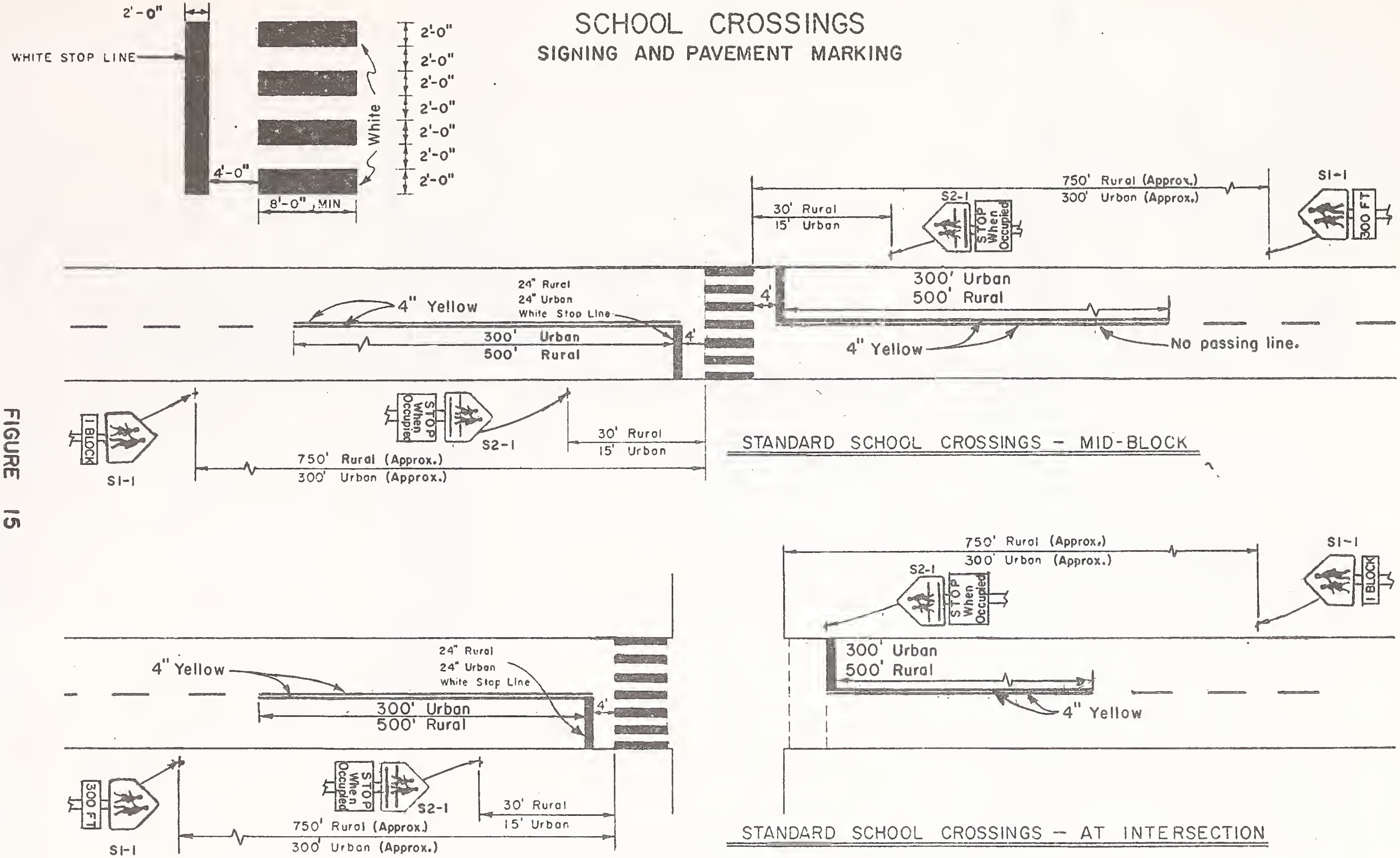
The length of the climbing lane beyond the crest of the hill is dependent upon the physical conditions of the roadway and is intended to allow the vehicle sufficient distance to safely reattain flow speed.

L. School Crossings

Pavement markings for school crossings shall be as illustrated in Figure 15. White longitudinal lines at a 90° angle to the crosswalk shall be 2 feet in width, spaced 2 feet apart. The crosswalk shall be a minimum of 8 feet wide and span the full width of pavement. A white stop bar, 2 feet wide, should ordinarily be placed 4 feet in advance of an parallel to the crosswalk and span all approach lanes.

The proper signs should be in place, if possible, at the time the pavement markings are laid down.

SCHOOL CROSSINGS
SIGNING AND PAVEMENT MARKING



STANDARD SCHOOL CROSSINGS - MID-BLOCK

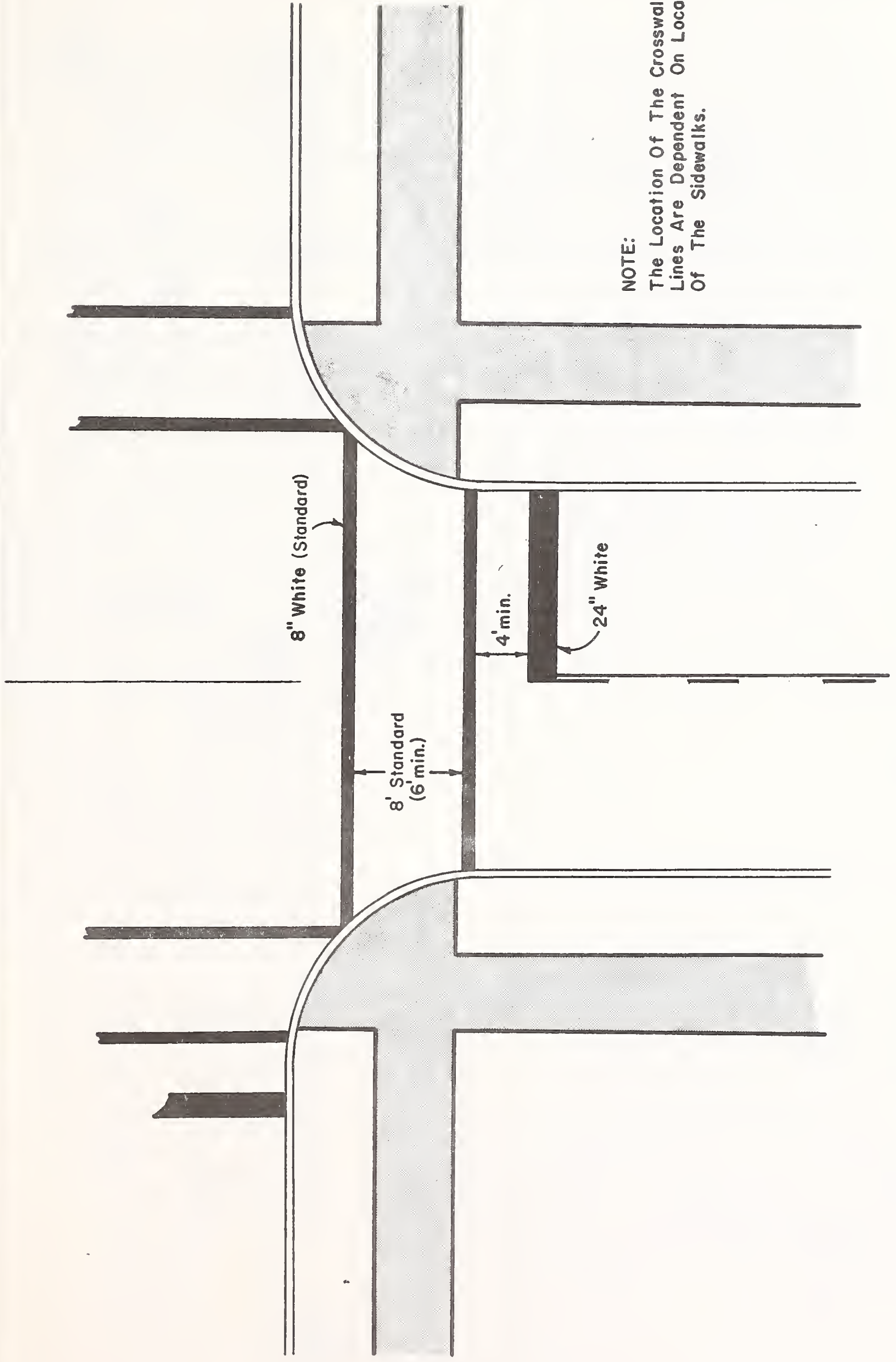
STANDARD SCHOOL CROSSINGS - AT INTERSECTION

When Advance School Crossing Flashing Beacons (bouncing balls) are mounted on Advance Warning Signs (S1-1) their location may vary from project to project but will normally be placed about 150 feet in advance of the crosswalk.

FIGURE 15

M. Pedestrian Crossings

An engineering study should be used to determine proper crosswalk placement. Optimum locations for crosswalks at points of pedestrian concentration include signalized intersections, intersectional approaches, traffic stops that have been designed to channel pedestrians into approved corridors and all intersections where a significant conflict between pedestrians and vehicles occurs. Crosswalk lines are 2 parallel solid white stripes normally spaced 8 feet apart (6 feet minimum). The widths of the crosswalk lines are normally 8 inches but may be increased to 24 inches in areas where vehicle speeds exceed 35 m.p.h., where an advance stop line is not provided, or in areas where crosswalks would not normally be expected. To discourage improper use of a crosswalk, both lines should extend from face of curb to face of curb or across the full width of pavement. Stop bars, where used, are 2 feet in width and should ordinarily be placed 4 feet in advance of and parallel to the crosswalk.



NOTE:
The Location Of The Crosswalk Lines Are Dependent On Location Of The Sidewalks.

TYPICAL PAVEMENT MARKINGS FOR PEDESTRIAN CROSSINGS

FIGURE 16

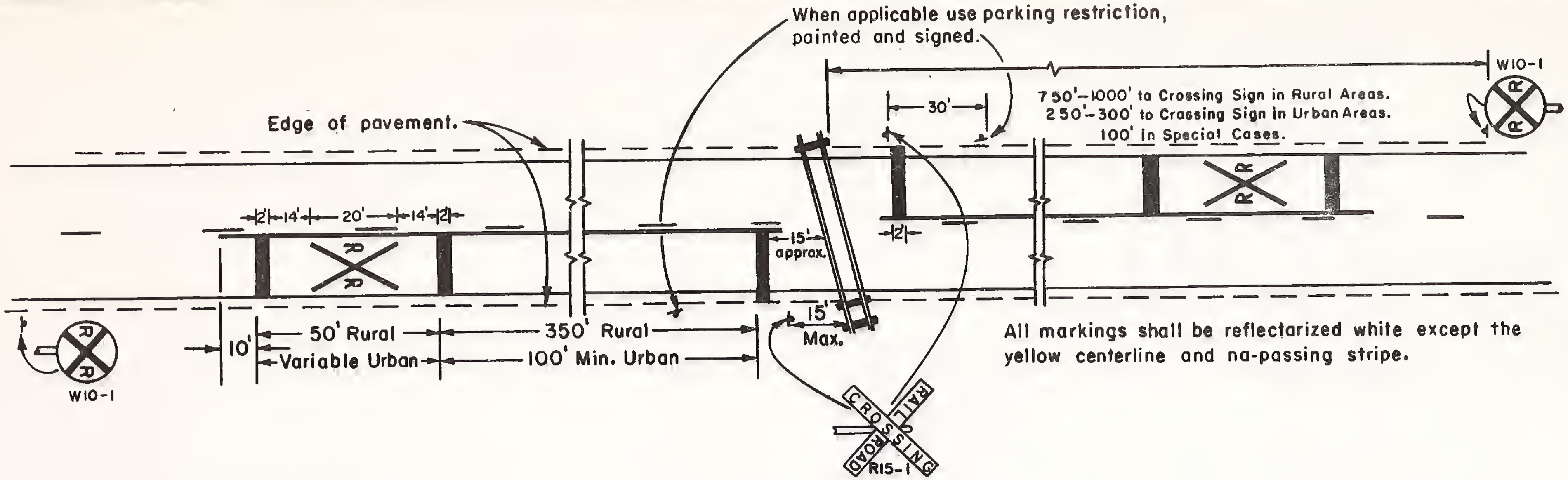
Revised May 1, 1978

N. Railroad Crossings

Pavement markings in advance of a grade crossing shall be essentially as illustrted in Figure 17. Identical markings shall be placed in each approach lane on all paved approaches to grade crossing where grade crossing signals or automatic gates are located, and at all other grade crossings where the prevailing approach speed is 40 mph or greater.

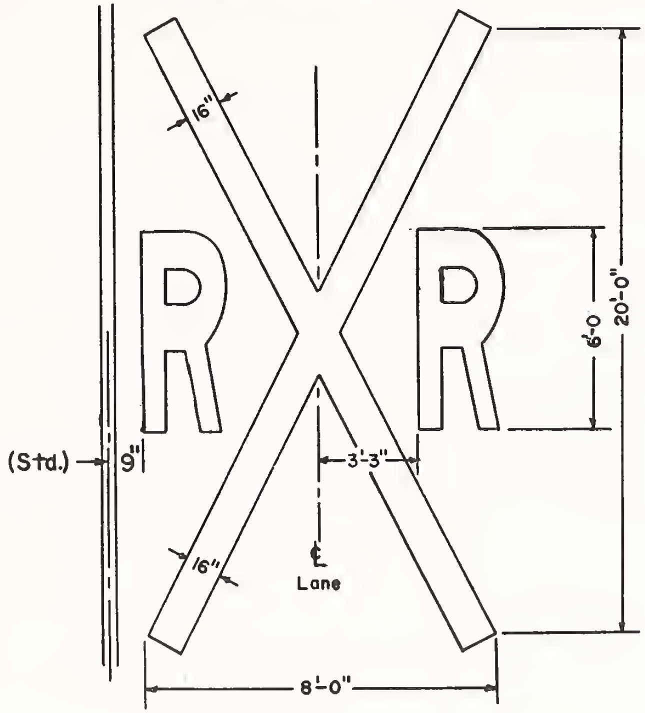
The markings shall also be placed at crossings where engineering studies indicate there is a significant potential conflict between vehicles and trains.

All markings shall be reflectorized white except for the no-passing and centerline striping. Stop bars will extend from the solid yellow no-passing stripe to the edge of pavement.



All markings shall be reflectarized white except the yellow centerline and na-passing stripe.

TEMPLATE DETAILS



FOR MULTI-LANE ROADWAYS

On multi-lane roads the transverse bands shall extend across all appraach lanes, and individual RXR symbols shall be used in each approach lane.

A three-lane roadway should be marked with a centerline for two-lane approach operation on the approach to the crossing.

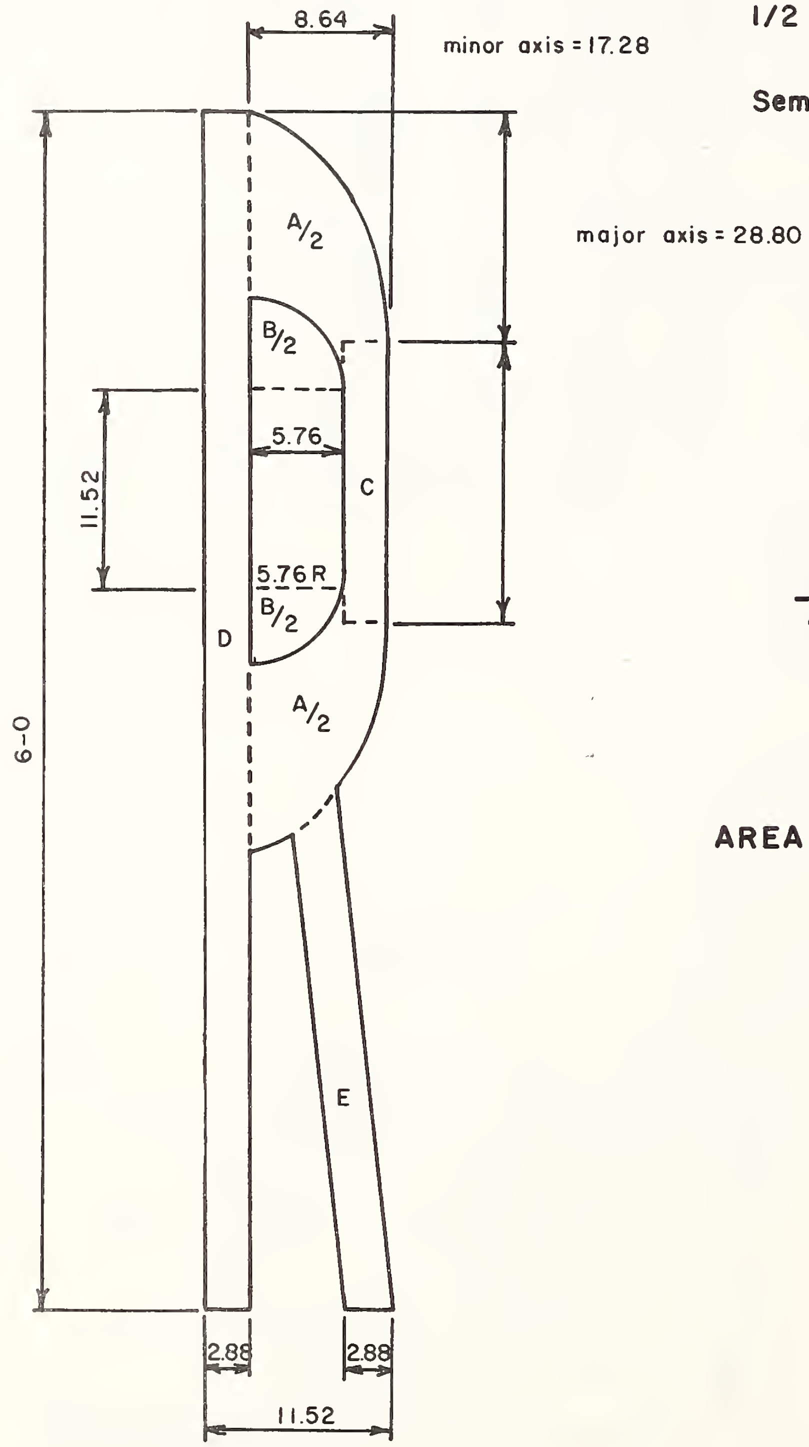
For multiple lane divided highways use supplementary W10-1 in the median. The median sign should be lacated 50' to 100' closer to the crossing than the W10-1 sign lacated on the outside shoulder.

Where applicable the stop line should be placed 8' Feet fram gate.

RAILROAD GRADE CROSSINGS

FIGURE 17

CALCULATIONS FOR TYPICAL RAILROAD CROSSING SYMBOL



1/2 Ellipse A = .78540 x 28.80 x 17.28 = 390.87
390.87 ÷ 2 = 195.43 sq. in.

Semi-circle B = 3.1416 x 5.76 = 104.23
104.23 ÷ 2 = 52.12 sq. in.

C = 17.28 x 2.88 = 49.77 sq. in.
D = 72.00 x 2.88 = 207.36 sq. in.
E = 28.80 x 2.88 = 82.94 sq. in.

195.43
52.12
49.77
207.36
82.94
483.38 ÷ 144 = 3.36 sq. ft.

AREA OF CROSSBUCK = 54.34

54.34 – X-BUCK
3.36 – R
3.36 – R
61.06 sq. ft. = 1 gal. of paint

O. Word and Symbol Markings

These markings are not to be used for mandatory messages except in the support of standard signs. The markings are used on approaches to intersections to supplement Lane-Use-Control signs indicating the types of movement that are permitted from specific lanes. One one-way streets the straight-through arrow may be used near intersections to indicate the proper direction of traffic flow (figures 18 and 19). When a lane requires word and/or symbol markings then all adjacent approach lanes shall also be marked with the appropriate word and/or symbol markings.

TYPICAL ARROW PAVEMENT MARKING SYMBOLS

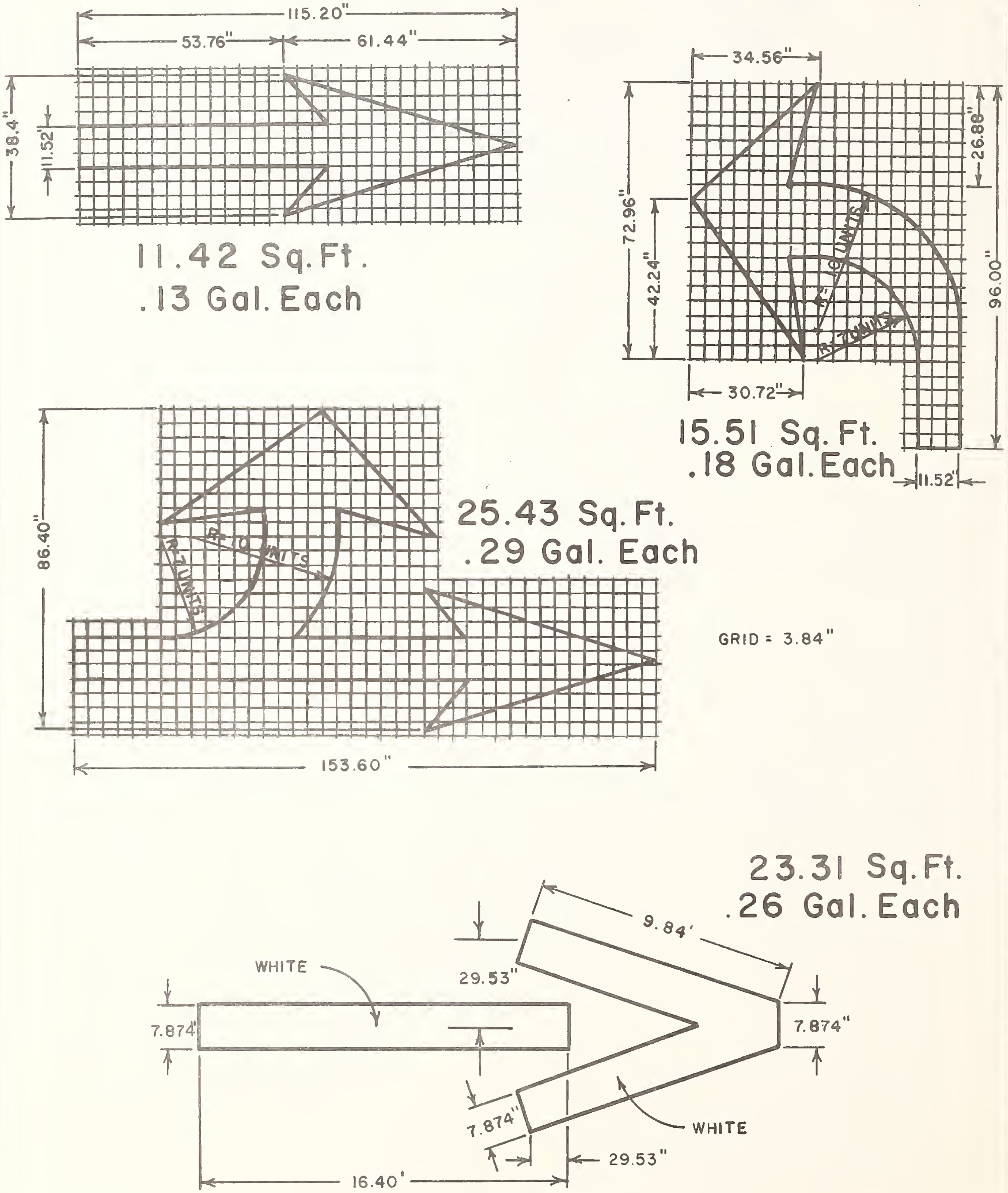


FIGURE 18

ELONGATED LETTERS

4"X8" GRID

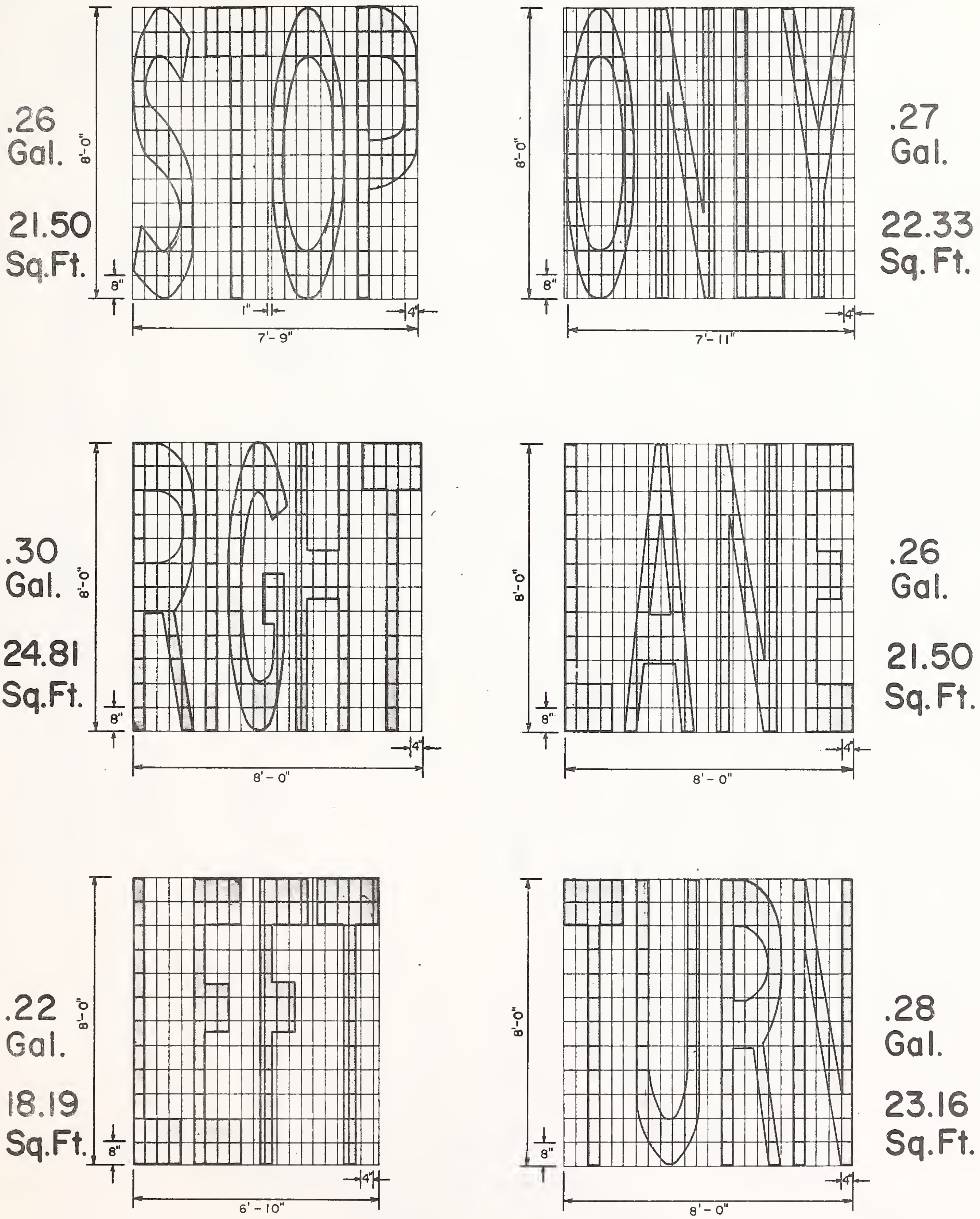


FIGURE 19

P. Parking Space Limits

Although the Department of Highways does not normally mark parking space, Figure 20 has been included to illustrate the normal limits of such zones. Parking limits in relation to intersections should conform to this standard in order to provide sufficient sight distance and minimize interference of vehicles parking and unparking.

STANDARD PAVEMENT MARKINGS

PARKING SPACE-LIMITS & STALLS

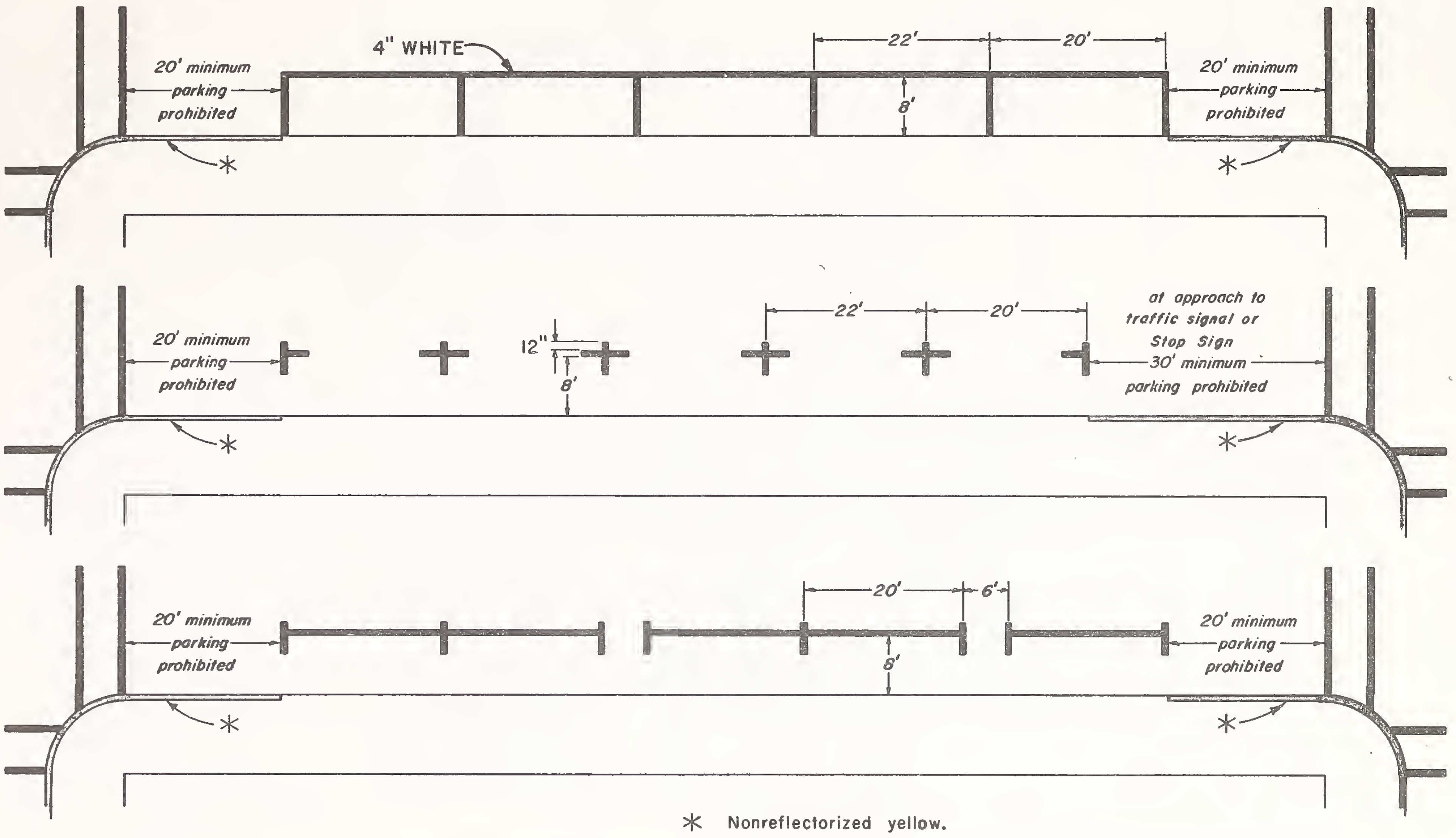
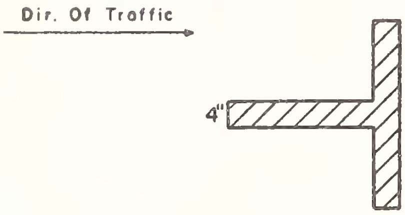
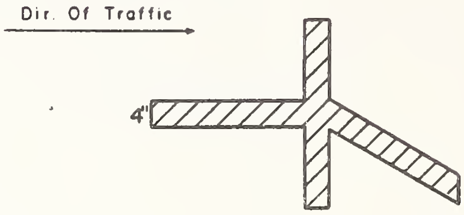


FIGURE 20

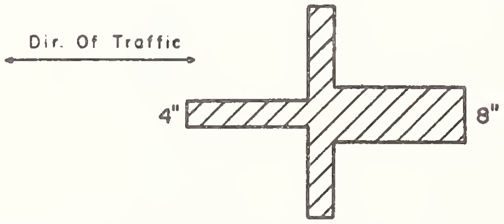
STRIPING LAYOUT SYMBOLS



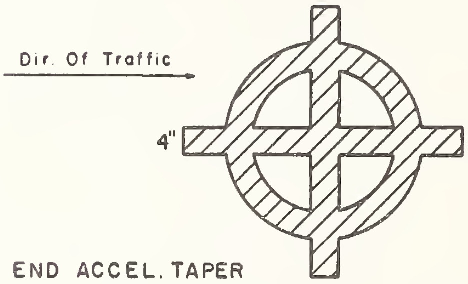
① END OF LINE



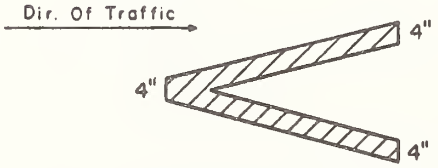
② END LINE - BEG. NEW LINE AT ANGLE



③ END 4" LINE - BEG. 8" LINE



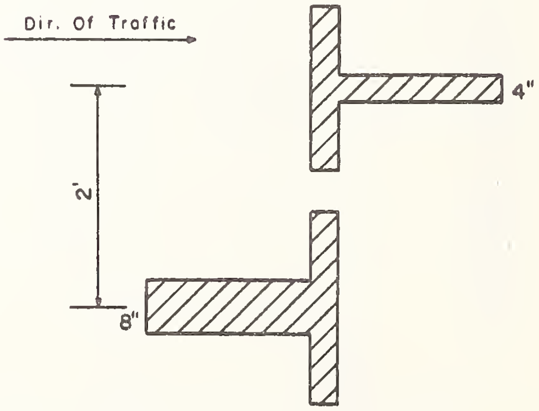
④ END ACCEL. TAPER



⑤ BEG 8" GORE MARKING ON DECEL. LANE

NOTE:

These are standard layout symbols to be used in the typical locations shown on the following page. They also have application on other pavement marking projects. Consistent and proper use of these symbols will promote understanding and eliminate confusion between layout crews, pavement marking crews and others concerned with pavement markings.

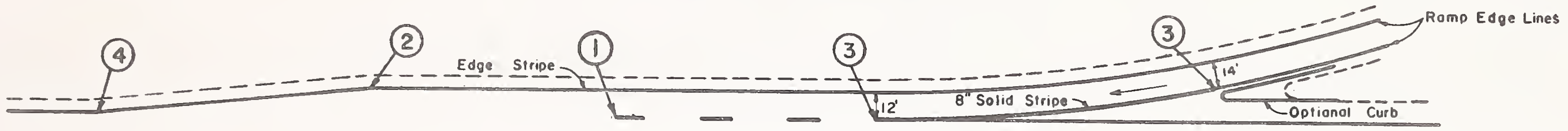


⑥ END 8" LINE - BEG. 4" LINE (2' OFFSET)

FIGURE 21

TYPICAL USE OF STRIPING LAYOUT SYMBOLS

PARALLEL ACCEL. LANE



Parallel deceleration lanes to be striped similar to parallel acceleration lanes.

1:50 TAPERED ACCEL. LANE

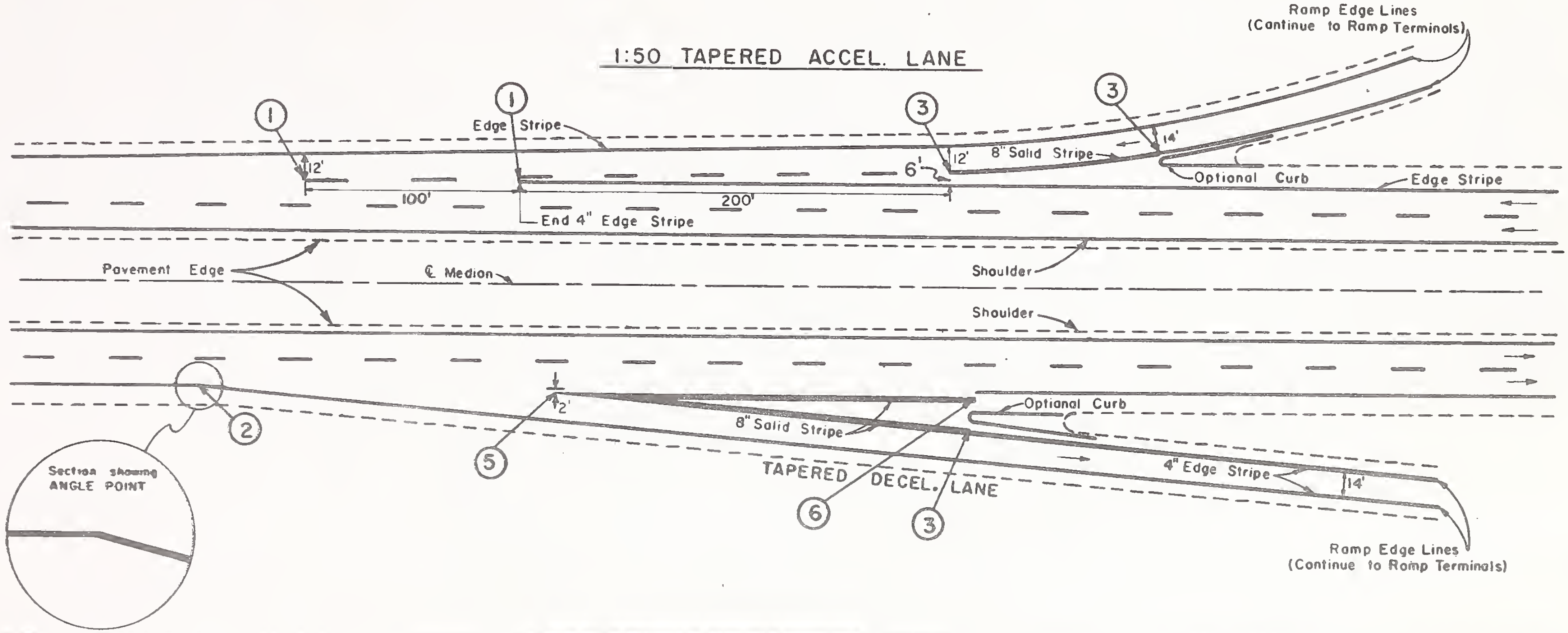


FIGURE 22